AD-A047 861 ARMY CONCEPTS ANALYSIS AGENCY BETHESDA MD F/G 19/1

NONNUCLEAR AMMUNITION COMBAT RATES PROGRAMMING FY 75/79 (AMMO75--ETC(U)

JUL 73

UNCLASSIFIED NL

1 OF 2

AD A047861

2

61

ADA047861

NONNUCLEAR AMMUNITION COM
PROGRAMMING FY 75-7
(AMMO P 75-79) (U)

FINAL REPOR

VOLUME IV. ANNEX C: METHODOL

PREPARED BY U.S. ARMY
CONCEPTS ANALYSIS AGENC
JULY 1973

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

1075

UNITED STATES ARMY CONCEPTS ANALYSIS AGENCY

8120 WOODMONT AVENUE

BETHESDA, MARYLAND 20014

NONNUCLEAR AMMUNITION COMBAT RATES

PROGRAMMING FY 75/79

(AMMO 75/79) (U)

FINAL REPORT

VOLUME IV. ANNEX C: METHODOLOGY

JULY 1973

(U) DISCLAIMER (U)

The views expressed in this study do not necessarily reflect approved Department of the Army views. However, the contents have been approved by the Commander, Concepts Analysis Agency. Comments or suggestions should be addressed to:

Commander
USA Concepts Analysis Agency
8120 Woodmont Avenue
Bethesda, Maryland 20014

Attn: Director of War Gaming

VOLUME IV. ANNEX C: METHODOLOGY

TABLE OF CONTENTS

(U) FOREWORD (U)

This volume presents the models which compose the ammunition rates methodology. These models are exercised with the basic data presented in Volume V to generate the ammunition rates for Europe as included in Volume II and for the Pacific as included in Volume III.

VOLUME IV

ANNEX C. METHODOLOGY

1. INTRODUCTION. This annex presents a technical description of each of the models included in the ammunition rates methodology. The models are exercised with the basic data contained in Volume V to develop the ammunition rates presented in Volume I, the main body of this report.

2. PURPOSE. This volume serves to provide under one cover the model description and also a discussion of the side analysis techniques used to develop the ammunition rates for bulk allotment items.

3. GENERAL. Each of the models is presented in an appendix directed exclusively to the model description. The concluding part of each model description consists of the principal assumptions made in developing and using the model.

APPENDIX I

TANK/ANTITANK SIMULATION MODEL

1. INTRODUCTION

a. The Tank/Antitank Simulation (TATS) Model is an expected value combat simulation of the following types of weapons:

(1) Tank weapon systems, both primary and secondary.

(2) Antitank guns and guided missiles.

(3) Armored personnel carrier and infantry combat vehicle weapon systems.

(4) Direct fire assault weapons.

b. The model simulates a two-sided engagement involving platoon-to-battalion sized forces. The principal products of the simulation are the ammunition expenditures and the weapon losses of various engaged weapon types.

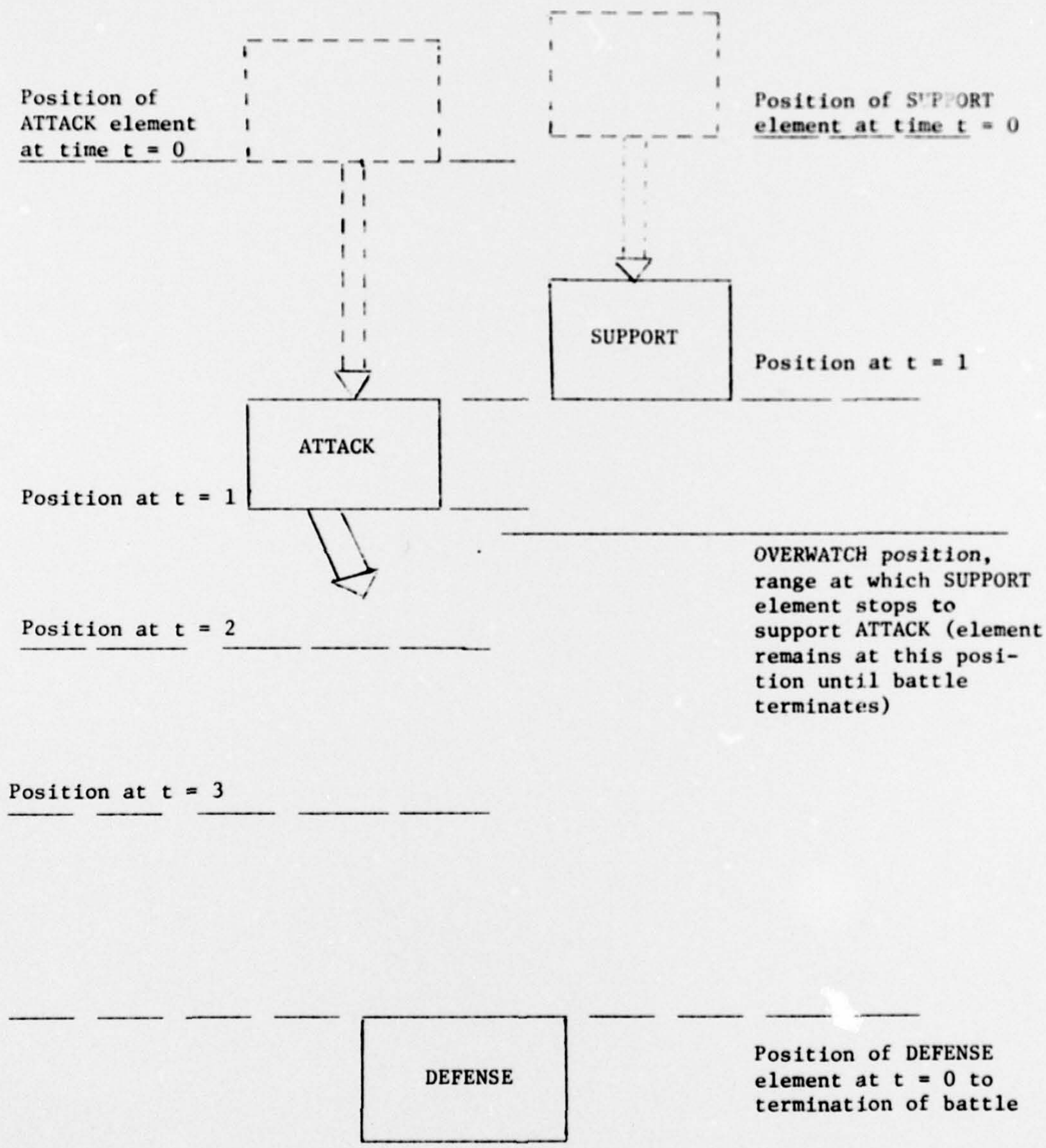
2. THE SIMULATED ENGAGEMENT. The general concept of the battle simulated by TATS is a stationary Defense force under attack by a force consisting of an Attack force element and a Support force element. Figure V-1 depicts the basic combat situation in which the Support element advances to an overwatch position and provides a base of fire for the Attack force.

3. GENERAL MODEL METHODOLOGY

a. Initial Condition Input Requirements. In order to simulate an engagement, certain elements and conditions must be specified for the beginning of the battle by the user of the model.

(1) Force Specifications. The attacking force is composed of an Attack element for all engagements and a Support element which can be played optionally. There must be a stationary Defense force. Each

Figure V-1-- Movement of Forces in the TATS Model



of the opposing force elements are specified by the number of their weapon elements, which can be a maximum of 10 weapons for any one force, and by the depth of the force.

(2) Weapon Element Specifications. Each element of weapon type must have the following information specified:

(a) Number of weapons in each type.

(b) Whether or not the weapon type is auxiliary to another weapon type, and if so, to which type.

(c) The maximum and minimum range at which any effective probability of kill; i.e., at least 0.01, exists against any of the opposing targets.

(d) Sustained rate of fire.

(e) Whether or not the weapon type is to be counted in terminating the battle due to combat losses.

(3) Target Priorities. The priority of fire for each weapon type against each target type of an opposing force is specified by a number from 0 to 10. The greater the number the higher the priority, where a zero indicates no firing at the target.

(4) Detection Limits. The maximum range limits of detection of each target type by each weapon type of an opposing force are specified in metric units. These limits should be indicative of the maximum detection ranges for unmasked terrain with vegetation representative of the battle area.

(5) Force Relative Location Information. The initial center-to-center distance between the Attack force and the Defense force, and the Attack initial movement rate must be input. If there is a Support force, the initial center-to-center distance between the Support and Defense forces, and the Support movement rate must be input. From these initial conditions, and subsequent conditions of a similar description

updated by the iterative operations of the model, the opposing force elements that are capable of engagement in the time interval are identified. The distance between the opposing elements is calculated on the basis of their positions at the end of the preceding time interval. The maximum effective ranges of the weapons on each side are examined to determine which weapon types within each force can fire on the opposition and the depth into the opposing force which they are capable of firing. At this point, it is known which weapons can fire.

b. Principal Model Operations. To simulate an engagement, the model applies, in time sequence, a recursive time-step attrition technique. An interval of one second or less is selected for the successive time steps, and the interactions between the opposing forces is examined at the end of each interval. These interactions are determined by five principal algorithms or operations which determine the acquisition of targets by weapon systems, calculate individual weapon system rates of fire, distribute the fire among the various targets, assess casualties among the targets, and describe the movement of the maneuvering force.

(1) Target Acquisition. This operation determines the number of targets by type acquired by each firer. Target acquisition depends basically on the number of targets present and the detection probability associated with the observer-target distance and the detection limits of the observer-target combination.

(2) Rate of Fire. A rate of fire is then calculated for each weapon type that has acquired targets in the preceding step. This rate of fire is based on several factors. These factors reflect the desirability to gain and maintain fire superiority, the desirability to conserve ammunition for the latter stages of the battle, and the tendency to fire more slowly at targets at the extreme range of a weapon. The actual number of rounds that a firing element expends during an elapsed time interval is a function of the rate of fire for the interval,

the number of targets detected, and the expected number of rounds from firer to achieve a target kill. For those weapon types with dual principal ammunition capability, the rate of fire of the annumition type more appropriate at the closer ranges is introduced at the crossover range for this ammunition type.

(3) Distribution of Fire. The rounds fired by each weapon type are distributed among the various targets on the basis of the number of targets acquired and the requirements for target kill, if the total number fired does not exceed the capability of the weapon to fire at its current rate over the current time interval. If the target kill requirements exceed the firing capacity of the weapon, the actual number of rounds fired at the various target types are limited to the firing capacity, and these adjusted numbers of rounds are weighted by relative target priorities.

(4) Casualty Assessment. The number of rounds fired by each weapon type against each opposing target type is combined with the appropriate probability of kill (P_k) to yield expected casualties. Consideration is given to the overlapping detections and fires occurring among individual weapons of the same generic type simultaneously directed at the same target, and to the overkill that may be exerted among the several weapon types capable of firing at individual targets common to these weapon types.

(5) Movement Rate. The rates of advance of the maneuvering force elements are then adjusted to reflect the effects of the volume of incoming fires. The velocities of the moving elements are adjusted in the same direction as the change during successive time intervals of the ratios of primary weapon kills among the Defense force to the total kills of the Defense and the respective moving forces. That is, if the

ratio of Defense force weapons kills to the sum of Defense and Attack force weapon kills increases, the rate of advance for the Attack force increases. Similarly, if the ratio of the Defense force weapons kills to the sum of kills among the Defense and Support force decreases, the rate of movement for the Support force decreases. If an overwatch position has been specified for the Support force, the model will set the Support movement rate equal to zero when the Support force has advanced to this position. After the movement rates are adjusted, the position of each moving force is adjusted, and the model proceeds to the next time interval.

c. Simulation Termination Criteria. The iterations continue until one of the following user specified criteria is fulfilled:

(1) The Attack, Attack and Support, or Defense force elements have been attrited to a specified fraction of their original size.

(2) The Attack element has penetrated to within a specified distance of the Defense element.

(3) The specified maximum duration of the battle has been exceeded.

4. PROGRAM LOGIC FLOW. The following flow chart Figure IV-2 illustrates the logic flow of the TATS program discussed in the previous paragraph.

5. INPUT FOR THE TATS MODEL

a. Required Input. In addition to the user input requirements discussed in paragraph 3a, a requirement of probability of kill (P_k) data is required for each ammunition round type fired with each weapon-target combination to be played in the model. The form of this data is in two-digit probability values as a function of range from zero range to the maximum range considered in intervals of one-tenth of maximum range. As targets are considered to be exposed while attacking and in hull defilade while defending, a set of P_k data for each of these target profiles is used.

Figure IV-2-- TATS Program Logic Flow

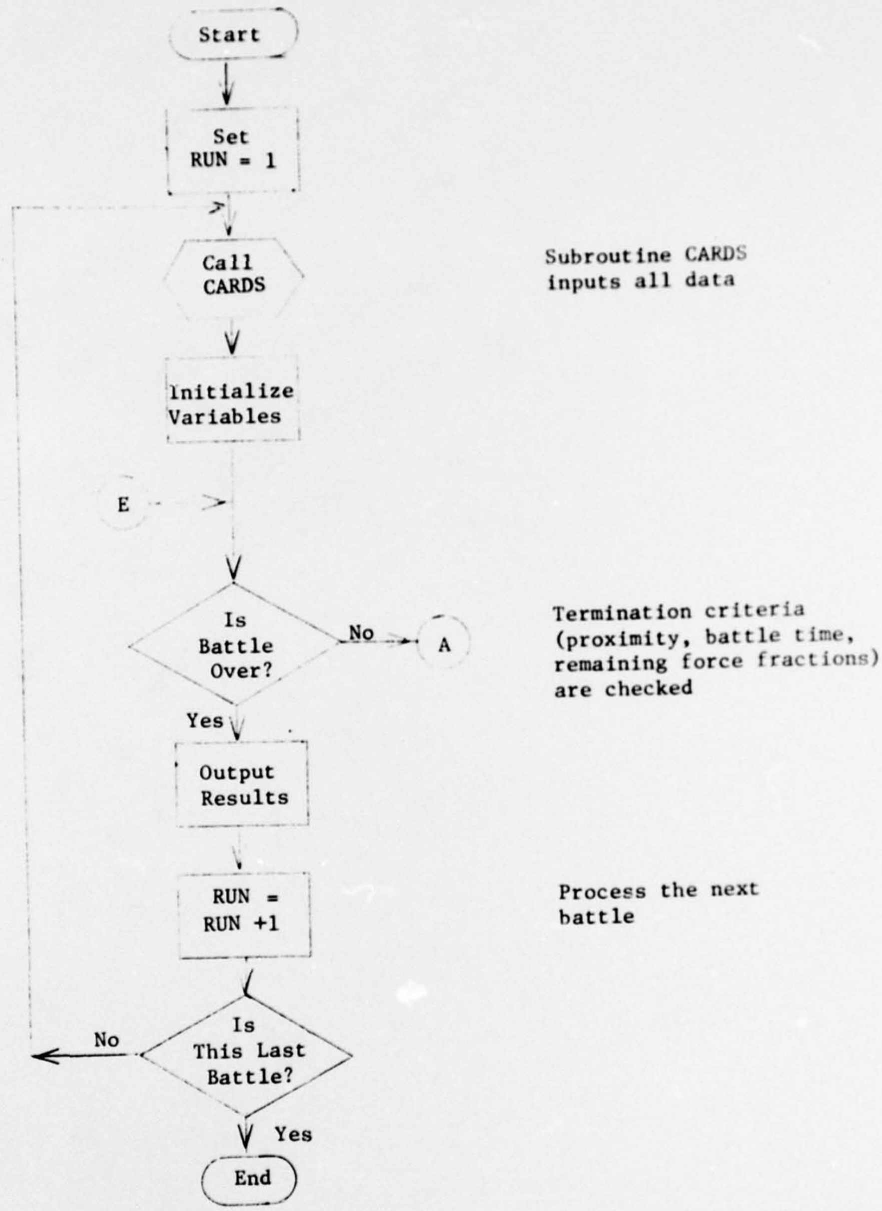
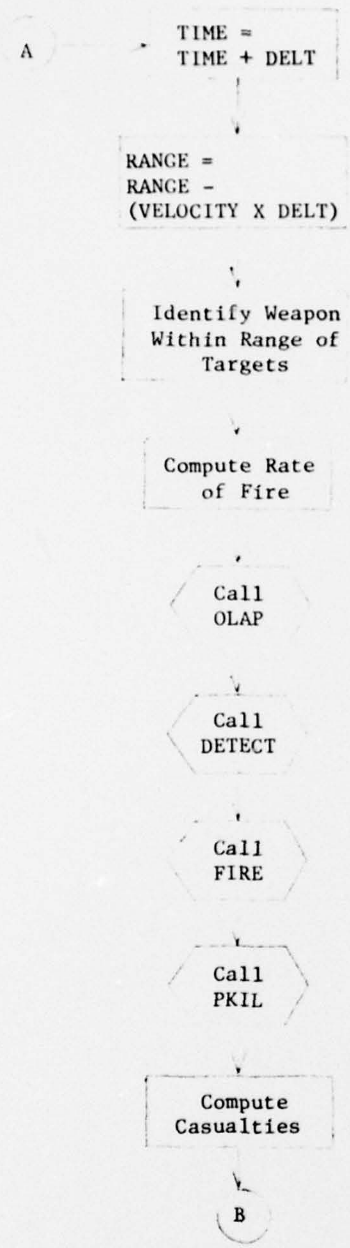


Figure IV-2-- TATS Program Logic Flow - Continued



Increment battle time.

Advance maneuver force elements.

Maximum firing range compared to separation distance.

Rate of fire updated based on intensity of conflict and stage of battle.

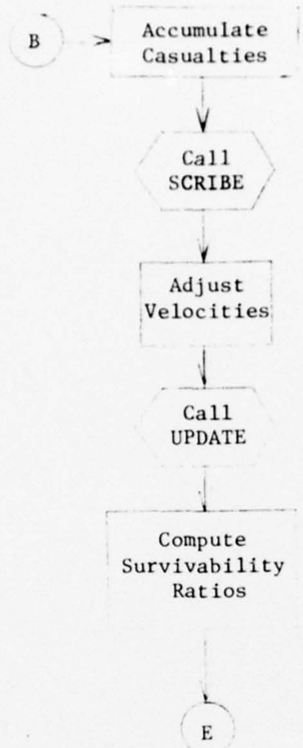
OLAP determines the fractions of opposing force capable of engaging each other.

DETECT calculates probability of detection of each target by each weapon type as a function of range.

FIRE determines the distribution of rounds fired for each firer-target combination.

PKIL calculates the probability of kill of a weapon firing at a target at a given range.

Figure IV-2-- TATS Program Logic Flow - Continued



SCRIBE summarizes and prints distribution of fires and casualties by weapon-target combinations.

The velocities are adjusted in accordance with the intensity of the battle.

UPDATE subtracts casualties from the force element prior strength values.

b. Optional Input. Optional refinements in the play of the model can be introduced by the input of any of the following data options by the user. Unless otherwise indicated, the data can be input to apply to either the Attack, the Support, or the Defense force.

(1) Waiting Time. The game time spent before the force begins to fire.

(2) Masking Distance. The distance between the other maneuver force and the Defense force when this force stops firing.

(3) Overwatch Distance. The distance to the Defense force at which the Support force stops advancing so as to provide a base of fire for the Attack force.

(4) Hold Fire Specification

(a) In the case of the Attack and Support force, this is a distance moved by an individual weapon type or the game time elapsed before this type weapon can open fire.

(b) In the case of the Defense force, this is the distance moved first by either the Attack or the Support force or the game time elapsed before the Defense can open fire.

6. OUTPUT FROM THE TATS MODEL. When any one of the three termination criteria discussed in paragraph 3c has been satisfied for a given situation of simulated battle, the battle will terminate and the model will execute the next battle situation. After the last battle is run, the model produces output in both print and punch card form. The output is organized according to the sequence of individual battle situations played.

a. Printed Output

(1) All model input data which were discussed in paragraphs 3a and 5 are printed out.

(2) At specified range separation points for either the Attack-Defense separation range or the Support-Defense separation range or both,

a print-out is made of the accumulated distribution of rounds fired for all weapon-target combinations in the opposing forces and the accumulation of target casualties for all weapon-target combinations in the opposing forces. The number of these range print-outs is limited to six for each the Attack force and the Support force.

(3) At the end of the time interval in which a battle termination criterion is first satisfied, a statement is printed which identifies the termination criterion which was met, the battle time, the Attack-Defense separation distance, and the Support-Defense separation distance. This is followed by a block of print-out which gives the final accumulations of rounds fired and target casualties for all the weapon-target combinations played in the battle. The ratios of final strength to initial strength are displayed for each of the opposing force elements. A final strength status of the primary individual weapon types is also listed.

b. Punched Output. Output data to be used by an auxiliary program is punched out on cards. This program, named Tank/Antitank Accumulation (TATA) program, is discussed in paragraph 7 which follows. For each tactical situation, a card is punched showing the identification number of the situation together with the number of weapon types in each of the Attack, Support, and Defense forces. This card is followed by a card for each weapon type in each force. Each card shows two identification codes for the weapon type, one numeric code and one alpha-numeric code. Also shown are the initial strength of the weapon type, the number of casualties inflicted on the weapon type, and the number of rounds of ammunition fired by the weapon system; in addition, if the weapon is an auxiliary weapon, the primary weapon is identified for accounting purposes.

7. TANK/ANTITANK ACCUMULATION (TATA) PROGRAM. The TATA program accepts the punched output from the TATS model and converts it into total stylized ammunition expenditures and weapons losses.

a. Input. In addition to the punched TATS output described in paragraph 6b for each situation, TATA requires the following input:

(1) Stylized period information, including period identification, the number of different type battle situations in the stylized period, and the frequency with which each of the type situations occurs in the stylized period.

(2) Basic load composition for the various Blue weapon systems.

(3) Factors which represent firing of other rounds in the basic load at nonarmor battle targets in proportion to what was fired by TATS in the simulated armor battles.

(4) A factor representing the fraction of total destruction or K-kill losses to the number of mobility-or-firepower (M-kill or F-kill) casualties of the weapons systems generated by TATS.

b. Program Operation. For each battle situation, the numbers of Blue auxiliary or nonarmor battle fire are computed for each ammunition round type based on the factors input and the number of rounds fired by TATS. The K-kill factor is multiplied by the number of M-or-F weapon casualties for both Blue and Red weapons. For each Blue weapon type the number of rounds fired is subtracted from the total initially available in the basic load to obtain the expected number of rounds remaining on the weapons. The number of weapons suffering K-kills is then used to multiply by the number of rounds remaining with the weapons to obtain the number of rounds by type which are considered lost in the battle. The situation frequencies are treated as multipliers of the number

of rounds fired and the number of weapons lost for both M-or-F kills and K-kills. The resulting products of rounds fired and weapons lost are summed over the entire stylized period.

c. <u>Output</u>. The stylized period sums mentioned above are tabulated by individual weapon and ammunition round type according to the number of rounds fired by TATS in the armor battles, by other nonarmor fires, by the sum of total rounds fired, by the number of rounds lost, and by the total round expenditures. The number of casualties of both the Blue and Red individual weapons types is also tabulated for the entire stylized period according to mobility-or-firepower (M-or-F) casualties and complete (K) kills.

8. <u>MODEL ASSUMPTIONS AND LIMITATIONS</u>. Certain assumptions and limitations are designed into the model to develop an expected value combat model that is realistic, fast, and economical.

a. <u>Assumptions</u>

(1) Defensive weapons fire before being fired upon.

(2) Once initiated all actions and interactions are continuous. Such actions include:

(a) Target Acquisition

(b) Maneuver Force Movement

(c) Weapon Firing

Blue wins??

(3) The movement rates of the Attack and Support forces will range between 66 percent and 100 percent of their initial velocities.

(4) All probabilities are treated as expected values in deterministic processes and not random variables in Monte Carlo processes.

(5) Terrain masking reduces the target detection probability beyond the mask of zero, but does not affect the detection probability in front of the mask.

(6) The probability of target detection is a function of three variables, the maximum detection limit on unmasked terrain for the weapon-target combination, the weapon-target separation distance, and the time interval. The general form of the detection probability equation is:

$$P_D = \left[EXP \left(\frac{-K \bullet R^2}{L^2} \right) \right] \bullet \Delta T$$

where P_D = Probability of detection

K = An empirical constant that determines the shape of the detection curve. (K = 6.9) → 8

R = Separation range between weapon and target.

L = Detection range limit for the weapon-target combination.

Δ T = Time increment

(7) The width of all forces can be ignored and a single axis of approach for the attaching forces is applicable.

b. Limitations

(1) Ten weapon types per force element.

(2) Two maneuver forces and one defense force.

(3) Uniform movement of all weapons within a particular force.

(4) Hold fire for a particular weapon type is applied against all targets.

(5) Casualties are assessed for only one kill criterion, depending on probability of kill input data.

(6) Only direct fire weapons can be simulated.

(7) No defending weapon can be fired upon until that weapon begins firing. At that time, the defending weapon becomes available as a target.

(8) Reconstitution of reinforcement of either side is not permitted in the model.

(9) Ammunition resupply to either side is not considered. Each weapon is provided an unlimited supply of ammunition.

APPENDIX II

INFANTRY ANTIPERSONNEL WEAPONS MODEL

1. INTRODUCTION. The model used to simulate antipersonnel weapons organic to infantry units is known as the infantry combat model (ICM).

2. GENERAL METHODOLOGY

a. The general concept for this simulation is based on a description of two opposing ground forces which are composed of varying sized units. The unit size for a given situation may vary in specific numbers but the small arms and indirect fire probability of kill and ammo expenditure tables are based on platoon-sized units. The results from the model are generated primarily from these tables, and the unit sizes should be described accordingly.

b. Each situation is evaluated on the basis of assessing casualties and ammunition expenditures for both sides in successive 2-minute intervals. At the end of each time interval, casualties are assessed, weapons are attrited, expended ammunition is accumulated, attacking units are advanced, and a decision is made as to whether the action should continue or cease.

c. Each engagement is repeated a number of times (replicated) in order that a good average of results can be obtained for any given situation.

d. The factors which affect the assessment at the end of each time interval are: time of day; type of terrain; distance between opposing forces; type and number of small arms weapons available; type and number of indirect fire systems supporting each side; detection capability of opposing force; movement rates; number of personnel in each unit; reserve forces; and mission type of opposing forces. These factors define how the model simulates the close combat exchange between opposing forces.

3. FORCE DESCRIPTIONS

a. In order to achieve a weapon/target combination for the opposing forces, it is necessary to develop a method of distributing the small arms weapons and personnel for a given infantry situation. This is accomplished by dividing the front into lanes and distributing the forces throughout the lanes. The concept of lanes is used to allow the scenarios to be played with different combinations of forces being engaged at the same time.

b. Lanes are developed from two aspects, that of the attacker and that of the defender. Each side is divided into the same number of lanes. Each lane for the attacker must define the personnel and small arms weapons of which a platoon-sized unit is comprised. This definition is important because of the manner in which the P_k tables were developed. The attacking force is the only side that advances during the simulation. Each attacking lane (platoon) advances at some determined rate based on a movement rate formula such that the individual movement rates vary; thus, the distances between lanes vary dynamically as the simulation progresses.

c. The defender forces can be divided into units smaller than a platoon such that a given number of lanes make up a platoon-sized unit. The number of subunits the defending platoons can be subdivided into can vary by platoon but the forces they are comprised of should be evenly distributed if possible. This is important when the lanes are augmented by reserve forces.

d. The simulation is controlled such that each lane is primarily engaged against the lane directly opposing it. This situation can change in the condition where a defender's sublane is 100 percent killed and its opposing attacking lane can direct its fire at the adjacent subunit of that defender's platoon. This means in effect that each subset engagement of attacking platoons to a defending platoon is an independent

engagement with respect to the close combat battle. Figure IV-3 provides a further explanation of this concept. As time intervals pass, attacking platoons advance and attrition is calculated. If at any time a defender's lane is totally killed, its opposing platoon effectively attacks the remaining subunits of that platoon. If at any time an attacker's platoon is totally killed, the effects of its opposing lane are no longer considered.

4. <u>INDIRECT FIRE</u>

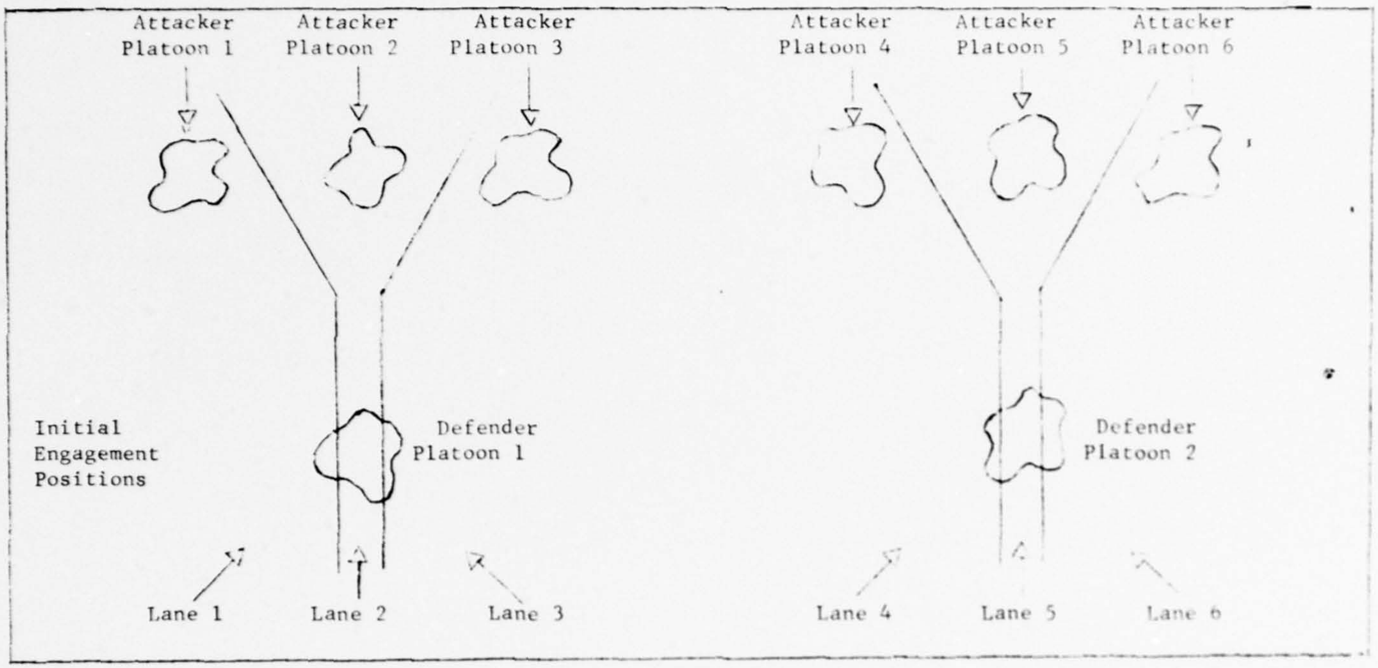
(a) In addition to the simulated engagement between close combat infantry, each force can have a system of indirect fire batteries supporting them. This support is applied to the opposing force continuously during the engagement. The effect of using the indirect fire capability in the model increases the casualties of the opposing forces thus affecting the movement rate of the attackers and the small arms effectiveness of each side.

(b) Indirect fire is applied by a rank order of priority by system type. Each system can have any number of batteries assigned to it. The fire control states that only one battery can fire on a platoon during any given time interval. The selection of which platoon gets fired on is determined by the firing history of each battery and the detection history of each lane.

5. <u>RESERVE FORCES</u>

a. The regular on-line forces are augmented by reserve forces based on the user selected critical value which can be varied for each specific engagement. There is a critical value selected for both the attacker and defender. When the specific side's critical value is first exceeded this triggers the reserve routine for that side. The reserves are delayed a given number of minutes from this initial trigger time until being added to the front lines. This delay time is an input value and can vary as the user desires.

Figure IV-3 -- Force Description



b. When the delay time has passed, the reserves are added to the front lines on a lane-by-lane basis considering each lane's needs based on a ratio of casualties to initial personnel. The order of augmentation adds the same amount to each lane augmented.

6. MODEL LIMITS. Figure IV-4 defines the limits of the ICM as determined by the computer program. Some or all of the limits can be changed but such changes would necessitate program modification. Some of the elements listed refer to data tables that are part of the program code. The other elements refer to input values.

7. DYNAMIC LOGIC FLOW

a. The ICM methodology is structured in such a way that the scenario describes the initial force structures and other factors which define the parameters affecting the engagement. This information is read in from formatted punched cards and the engagement begins. Reference should be made to Figure IV-5 for an overall view of the decision and information flow.

b. The evaluation of the exchange is made at the end of each 2-minute time interval. Some information which affects the engagement in the next time interval is calculated and stored for use at that time. Time intervals are best thought of as the activities that take place between the beginning and ending of a 2-minute exchange. Thus, time interval one is the activities between 0 and 2 minutes with the results being evaluated at the end of the interval.

c. The first event evaluated during each time interval is to calculate the force ratio of the attacker to the defender and the casualty fraction for the attacker. These values are used in the critical value formula later.

d. The second event is to use the subroutine SMARMS to evaluate the effects of the exchange of small arms fire between both forces.

Figure IV-4 -- Limitations of ICM

	Minimum	Maximum
Total number of personnel per side	0	99999
Number of lanes per side	1	50
Number of small arms types per lane	0	7
Number of small arms types per side	0	7
Number of reserve lanes per side	0	99999
Number of personnel per reserve lane	0	99999
Number of reserve small arms types per lane	0	7
Number of indirect fire systems per side	0	5
Number of batteries per indirect fire system	0	50
Total number of batteries for all I.F. systems	0	50
Types of terrain (use only 1 per scenario)	1	3
Types of day time (use only 1 per scenario)	1	2
Types of missions (use two per scenario)	2	6
Range for small arms tables (in meters)	100	800

Figure IV-5-- Infantry Combat Flow Chart

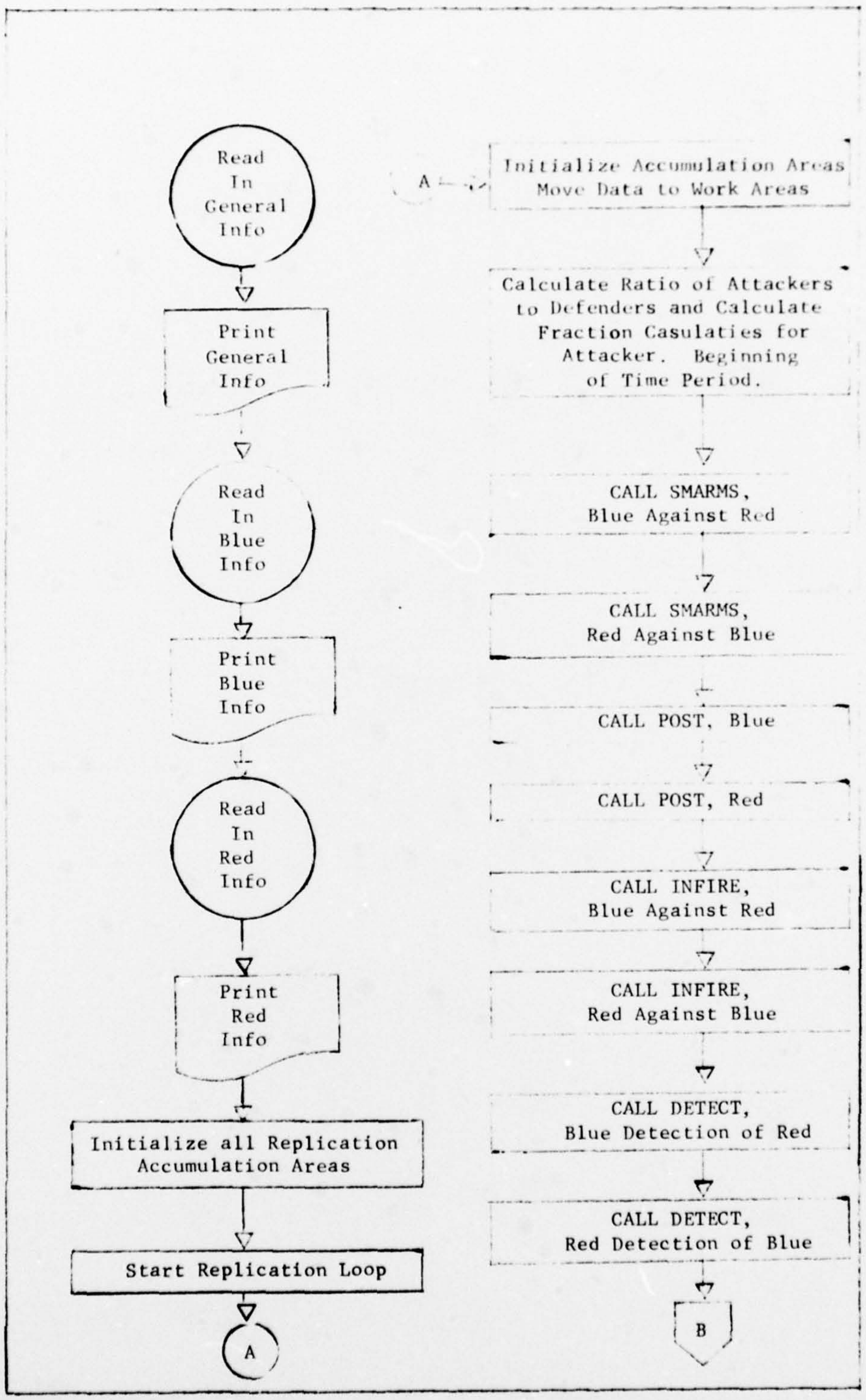
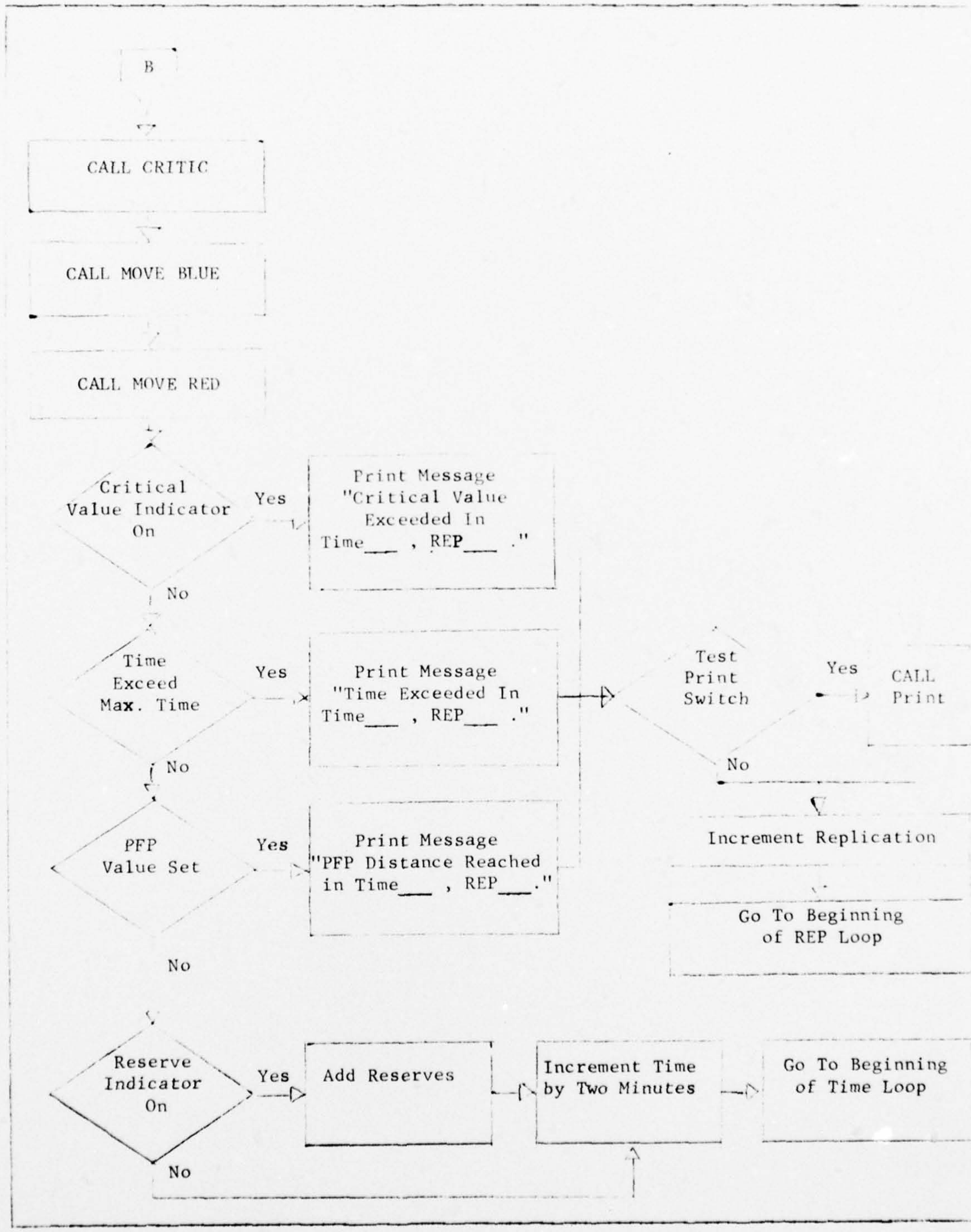


Figure IV-5-- Infantry Combat Flow Chart--Continued



This evaluation determines the number of casualties per lane, the type and number of small arms lost per lane and the ammunition expended by small arms type per lane. These calculations are based on such factors as the distance between lanes, the P_k and rate of fire of each small arms type, terrain, time of day, small arms weapon deletion rates, etc. Casualties and weapons lost are subtracted out of the current inventory in addition to accumulating the casualties, weapons lost, and ammunition expended.

e. The third event is to use the subroutine INFIRE to evaluate the effects of each force's indirect fire support. The firing of each battery, determination of the platoon to be fired on, and evaluating the results of such fire are the tasks of this routine. Each battery fires on a platoon-sized target. Only one battery can fire on a given platoon during any one time interval. Whether or not a battery can fire is determined by its firing history and the detections of the opposing forces from the previous period. The casualties and small arms weapons lost from indirect fire are subtracted out of the current inventories, and accumulation is made of casualties from indirect fire, small arms lost from indirect fire, and indirect fire ammunition expended by system.

f. The fourth event is to use the subroutine DETECT for the detection determination of opposing platoons. Detections made in a current time period affect the indirect fire systems' firing decisions during the next time period. Detection is based on a probability of detection curve developed for a given movement rate, distance between forces, and terrain.

g. The fifth event is to calculate the force ratio of the attacker to the defender and the casualty fraction for the attacker for the end of the time interval. These values are used in the critical value formula later.

h. The sixth event is to use subroutine CRITIC to determine if the user-selected critical value for either the attacker or defender has been exceeded. The critical value is a function of distances moved and the beginning and ending force ratios and fraction casualties. The calculated critical value is used to determine whether the exchange is to continue or stop. It also determines when reserve forces are called in if they are available.

i. The seventh event determines if the closest distance that can be reached before protective fire power commences has been reached. If it has, the exchange is stopped because this evaluation is outside the limits of this model.

j. The eighth event calculates the movement rate using subroutine MOVE and decreases the distance between opposing lanes accordingly. The defending forces do not advance as they are assumed to be in fixed positions. The distance moved represents the distances the troops will move during the next 2-minute time interval. Once an attacking platoon is stopped due to a calculated movement rate, it remains stopped for the next three 2-minute time periods before continuing to advance

k. The ninth event is the augmentation of forces based on the critical value calculation for each side. The first time the critical value is exceeded for a specific side, that side's reserve forces are started toward the front lines. After a user-designated time delay, they are added into the lanes based on an order of most need by lane. The order of need is based on the fraction of personnel remaining for each lane. All reserves for a side are added in at the same time. The exchange continues from this point until either the critical value, the protective firepower or the maximum game time has been exceeded, at which time the action stops.

l. The output routine can be called under a number of options, but primarily is called at the end of the exchange after all replications

have been accomplished. The output averages the casualties, small arms weapons lost, small arms ammunition expended, and indirect fire ammunition expended. The averages are printed in report readable format and give the average results from the engagement.

8. PRINCIPAL ASSUMPTIONS. The principal assumptions made in the infantry combat model are listed in the following paragraphs.

a. The average opening range is 800 meters; all attacking personnel are dismounted by this range.

b. When a target comes within the maximum effective range of a weapon, the weapon starts to fire. (Maximum effective range is defined as the maximum range at which the weapon's P_k is non zero.)

c. Only one battery of the supporting indirect fire systems will fire at a given lane at any time.

d. No battle will terminate in less than 6 minutes.

e. The movement rate of the attacking units is functionally related to the casualties sustained by these units.

f. The commander of the attacking unit will utilize the number of casualties his unit has taken so far to predict casualties expected to achieve the mission. It is further assumed that the unit commander will base decisions on such estimates.

g. The commander of the defending unit will also base decisions on his estimates of strength for the defending and the attacking units.

h. The principal threat to the defending force is the advancing enemy infantry.

APPENDIX III

HELICOPTER ANTIARMOR MODEL

1. INTRODUCTION. The model used to simulate helicopters in an antiarmor role is known as the helicopter versus armor model (HOVARM).

2. GENERAL METHODOLOGY

a. The general concept for this simulation is based upon an armed helicopter fire team engaging an armored ground force.

b. The armored ground force may be composed of any number and mix of the following categories of armored vehicles up to the model limitations on the number of elements (20) - tanks, Quad-23 AAA, Twin - 57 AAA and APC vehicles.

c. The entire target array is assigned a cover status of open or partial defilade as initial mission input. This cover status remains constant for all passes and is used to govern the helicopter-launched missile probability of kill selection. The expected pass-to-pass intervisibility variations between the helicopters and ground target elements can be reflected through an additional individual pass input.

d. Each pass is evaluated on the basis of assessing expected casualties and ammunition expenditures for three distinct engagement phases. These phases are defined by the expected time for the helicopter crew to perform specific tasks - target detection and missile launch time, missile guidance time, and helicopter re-mask time. Each phase is stepped through in 0.2-second time intervals to continually update the helicopter position for purposes of assessing the results of the ground elements firing at the helicopter.

e. The factors which influence the assessment at the end of each time and/or phase interval are: ground target cover status; intervisibility between the helicopter and individual target elements; number and mix of target elements; detection capability of opposing force; time length of each phase; helicopter speed during each phase; and distance between the helicopter and each target element.

3. <u>ENEMY FORCE DESCRIPTION</u>

a. The target elements for a given situation are placed on a common grid and the location of each element is coded for input by means of a coordinate location system (left-to-right, bottom-to-top). The helicopter is always assumed to be attacking from South to North so the map target array may need to be skewed before it is transferred to the common grid.

b. The number of elements in the target array is limited to a maximum of 20 elements. Since the helicopters are assumed to normally be committed as a fire team of two each carrying four missiles, it is not difficult to select those 20 or less elements from a given array which would either be targets for the helicopters or influence the battle by firing back at the aircraft.

c. The assignment of a cover status to the entire array plus the designation of helicopter-to-target element intervisibility on each pass is based upon the military judgement of the gamer.

4. <u>HELICOPTER FIRE TEAM DESCRIPTION</u>

a. The normal armed helicopter versus armor engagement was assumed to consist of a 2-aircraft fire-team with each aircraft making four passes at the target array. The two aircraft may attack individually or simultaneously. Each pass begins when the aircraft breaks terrain masking and ends when the aircraft is re-masked following missile impact.

b. Each pass is broken into three distinct time phases. These phases are determined by the expected time required for certain events to take place[1]. The first phase begins when the aircraft breaks mask and begins the target detection process and ends at missile capture (three seconds after missile launch). The second phase begins at phase one termination and ends when the missile impacts on the target. The third phase begins at the termination of the second phase and ends once the aircraft has re-masked.

c. The rate at which individual targets fire at the aircraft during each phase of a pass is governed by suppression factors which are part of the input set. These factors are based upon military judgement and past studies[2]. These factors can be varied from pass to pass by input but are normally input at the start of the first pass and then updated to reflect expected destruction during previous passes.

d. The helicopter can be expected to abort the firing pass under certain conditions in an anti-aircraft weapon environment. In this study, the helicopter aborts in those cases where anti-aircraft fire is received prior to missile capture. The probability that this occurs is also based upon past studies[3] and military judgement and is input for each pass of the mission. Thus, the entire expected fraction of an aircraft that is still alive at the beginning of the pass is susceptible to losses inflicted by the ground weapons during phase one of the pass. However, at the completion of phase one, the remaining fraction of an aircraft which is expected to abort is temporarily removed for the remainder of the pass. This limits the aircraft ammunition expenditures and losses during the second and third phase of the pass. The expected aircraft abort fraction is then added back in prior to the initiation of the next pass.

---

[1]"Attack Helicopter Survivability as a Function of Exposure Time," USACDC-Systems Analysis Group, Fort Belvoir, Virginia, December 1971 (C).

[2]<u>Ibid</u>.

[3]<u>Ibid</u>.

e. The secondary armament expenditures for the aircraft are computed for each pass. However, it is assumed that these expenditures are suppressive in nature and do not result in any target element attrition.

5. MODEL LIMITS. Figure IV-6 defines the limits of the HOVARM model as determined by the computer program. Some or all of them can be changed but require program modification.

6. DYNAMIC LOGIC FLOW

a. The HOVARM methodology is structured such that the target array, helicopter team makeup, and other factors which define the parameters affecting the engagement are read in from formatted punched cards and the engagement begins. Reference should be made to figure IV-8 for an overall view of the decision and information flow. The flight path and phase definition are shown in figure IV-7.

b. The evaluation of the engagement is made at the end of each 0.2-second time interval for purposes of determining the current position of the aircraft and target element expenditures. Some information which affects the engagement in the next time interval is calculated and stored for use at that time. Additional evaluations and data storage are made at the completion of each phase of the pass. A summary of the results of each pass is determined and printed following the termination of phase 3, and a mission summary is calculated and printed following the last pass of the engagement.

c. The first event evaluated during each time interval is to compare the present range from each target element to the helicopter with the maximum effective range of the target element weapon system. If the aircraft is within range the number of rounds fired by each target element is determined based upon the applicable firing rate and suppression factor. This information is added to previous expenditures during the phase.

d. The second event is to update the position of the aircraft and determine new target-to-helicopter ranges for each target element. The time since the phase started is updated, and two time checks are performed. First, a check is made to see if the mid-phase range is stored for each target element. The second check is to determine if the phase has been completed. As a result of this check, either a new cycle is initiated through the above time events or final phase calculations are made.

e. The end of phase calculations consists of determining a cumulative probability of kill value resulting from the expenditures of all target elements and assessing damage against the target array resulting from the helicopter-launched missile at the completion of phase 2. The selection of a probability of kill value for a given target weapon system is based upon the average target-to-aircraft range and average crossing velocity during the phase.

f. The completion of the above calculations for phase 3 results in the end of pass summary. This consists of updating ammunition expenditures and losses for both the targets and the helicopter and printing a pass summary. If additional passes are to be flown, a new pass cycle is initiated; otherwise, the end of mission computations begin.

g. The end of mission summary consists of determining total targets kills, helicopter losses, and the exchange ratio. A final summary of mission results is then printed.

7. PRINCIPAL ASSUMPTIONS. The principal assumptions made in the HOVARM model are listed in the following paragraphs.

a. The armed helicopter can fly nap-of-the-earth to the missile launch points without drawing enemy fire.

b. At the launch point the aircraft unmasks and after a predetermined time can locate a target to attack.

c. If ground fire is received by the aircraft, the mission is aborted unless the missile has been launched and captured at which point the mission continues.

d. Fire from the secondary armament carried by the aircraft is adequate to suppress all ground weapons except tanks, AAA, and APC's.

e. At missile impact, the aircraft can remask within a short period of time so that it receives no additional ground fire while en-route to the next launch point.

f. The detection times and probabilities determined by the previously mentioned study[4] will fit the terrain and weapon systems being considered in this study.

g. The aircraft will not cross the FEBA during the engagement and will not be vulnerable to small arms fire.

h. The helicopters will use different launch points for each pass. Thus, the ability of the target elements to detect and fire at the aircraft is pass independent.

---

[4] Ibid.

Figure IV-6--Limitations of HOVARM

	Minimum	Maximum
Number of distinct enemy weapon types	1	5
Number of specific enemy elements in the target array	1	20
Number of aircraft involved in the mission	1	10
Total number of passes by all aircraft	1	20
Range points which define the probability of kill table for antiaircraft weapons	1	10
Crossing velocity points which define the probability of kill table for anti-aircraft weapons	1	10

Figure IV-7-- Phases of a HOVARM Pass

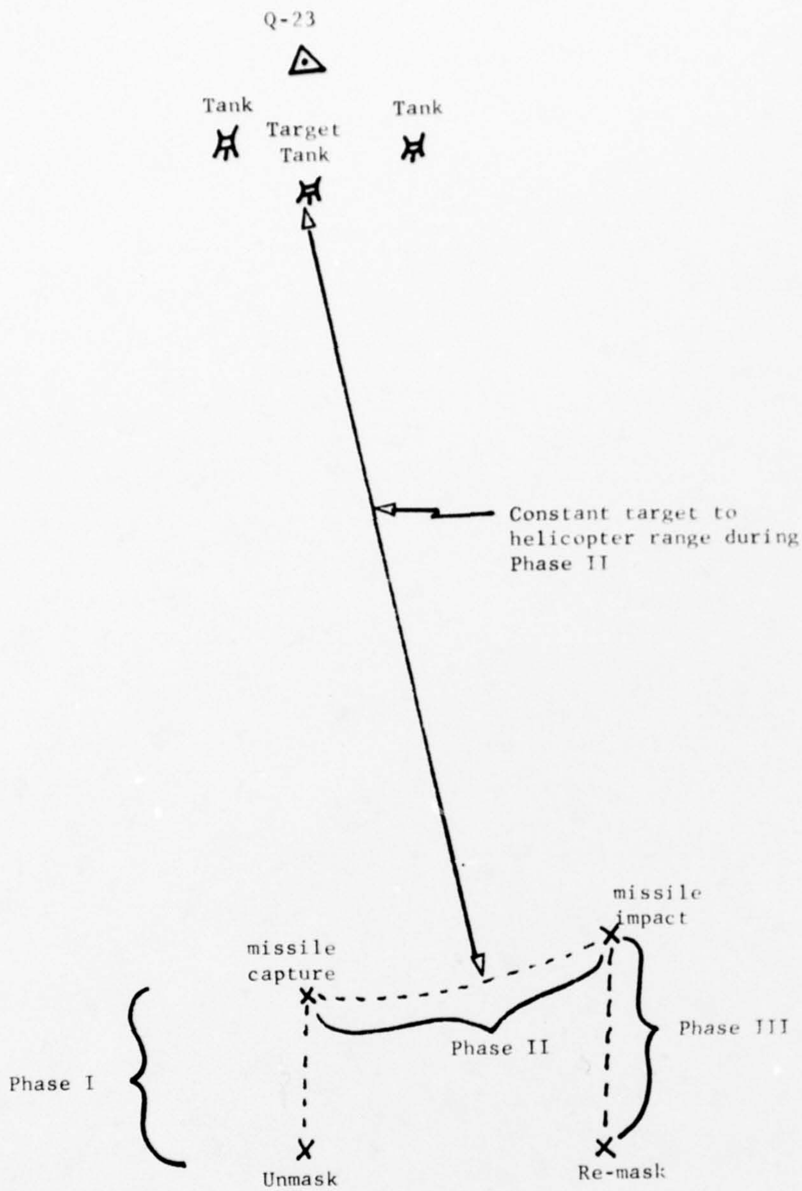


Figure IV-8-- HOVARM Flow Chart

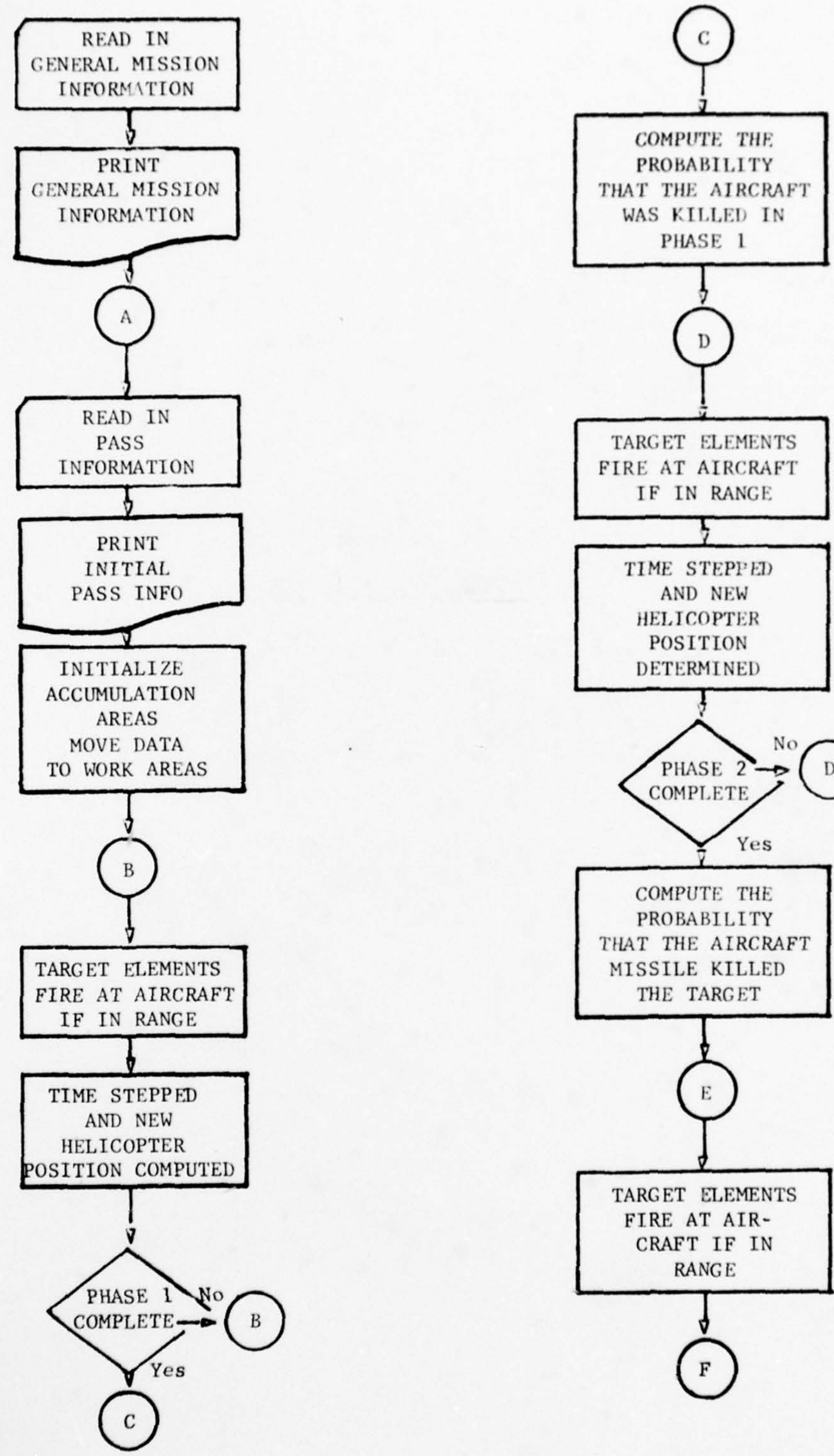
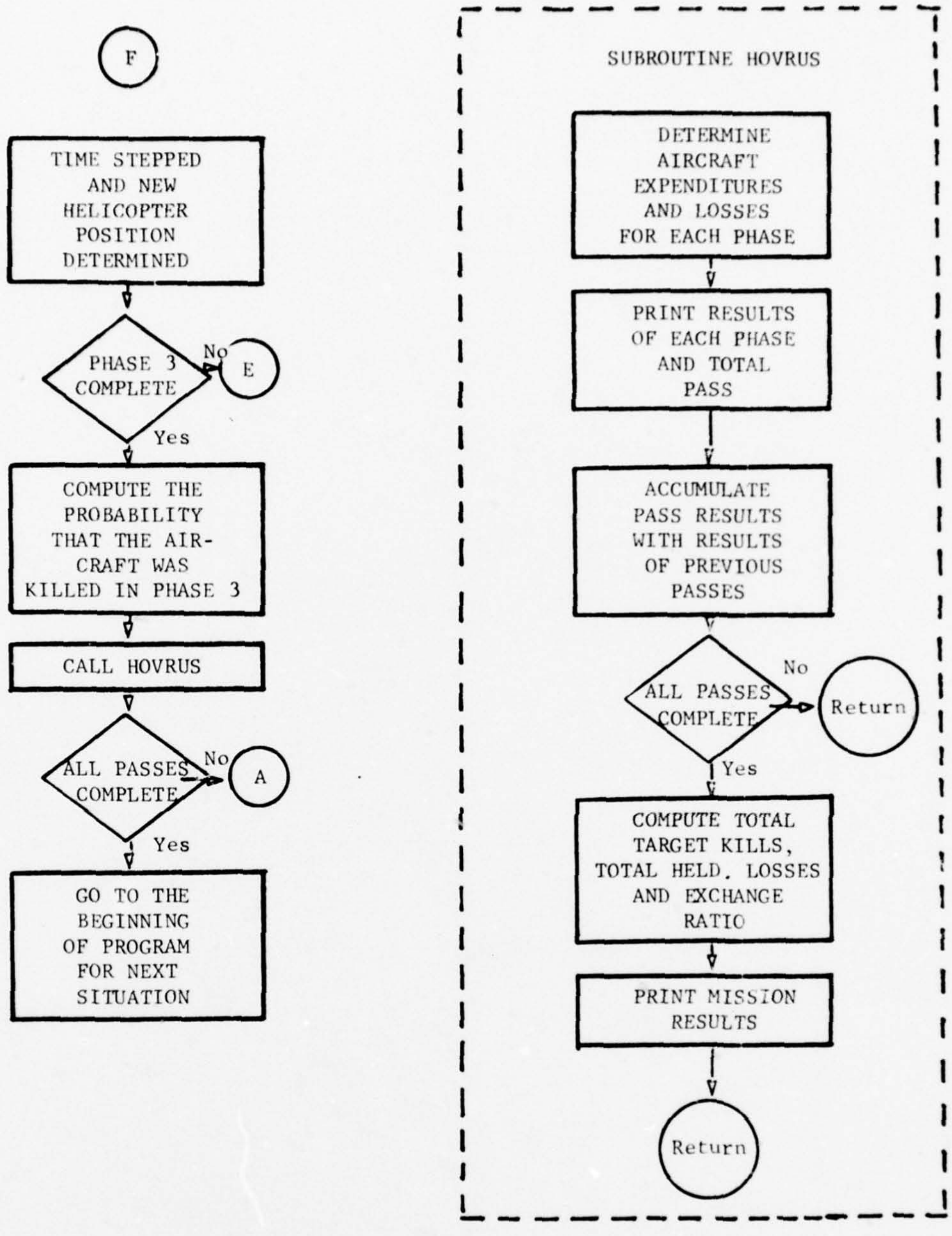


Figure IV-8--HOVARM Flow Chart--Continued



APPENDIX IV

HELICOPTER ANTIPERSONNEL MODEL

1. INTRODUCTION. The model used to simulate helicopters in an antipersonnel role is known as the helicopter versus personnel model (HOVER).

2. GENERAL METHODOLOGY

a. The general concept for this simulation is based upon an armed helicopter fire team engaging dismounted personnel-type targets.

b. The engagement begins with the lead aircraft initiating the first firing pass on the target. The aircraft are considered to be flying in a closed loop in pairs. As one aircraft terminates a pass, the second begins the next pass. At the completion of all passes, the model computes the ammunition expended by the aircraft, the expected aircraft losses, and the expected percentage casualties to the targets.

c. The number of rounds to be fired from each aircraft weapon system and the sequence of the firing are input for each pass. However, the model restricts these expenditures to that which the weapon can fire at a given rate for the time involved. Rounds left over from previous passes due to the above time restraint are made available for firing on subsequent passes.

3. ENEMY FORCE DESCRIPTION

a. The personnel targets for a given situation are placed on a common grid, and the location of each target is coded for input by means of a coordinate location system (left-to-right, bottom-to-top). The helicopters are always assumed to be attacking from South to North so the map target array may need to be skewed before it is transferred to the common grid.

b. The targets can be defined as being either rectangular or circular in shape. The position and size of the rectangular target is coded for input by defining the position of the lower left corner on the common grid together with the dimensions. The circular target is coded for input by positioning the center on the common grid together with a radius. The elements within each target can be uniformly or randomly distributed.

c. The aircraft are not considered to be vulnerable to small arms ground fire. However, the provisions are made for inputing the probability that the aircraft is killed on each pass. Thus, if there are antiaircraft weapons present in a given target array, the necessary kill probabilities could be obtained by first exercising the antiarmor helicopter model (HOVARM) utilizing the same speeds and pattern that will be used in HOVER.

d. The targets are considered to be stationary during the entire mission. However, provisions are made for changes in the posture of the target elements as the mission progresses. The fraction of the personnel in the target complex that are standing, prone, and in foxholes are input together with the time that this change will occur during the mission.

4. HELICOPTER FIRE TEAM DESCRIPTION

a. The normal armed helicopter versus personnel engagement was assumed to consist of a 2-aircraft fire-team flying in a closed loop. No provisions are made to separate passes by the lead aircraft from passes by the wing aircraft. That is, the wing aircraft is assumed to fly an identical pass to that which was just completed by the lead aircraft. However, the expenditures of the wing aircraft are reduced on the last pass to reflect an early breakaway from the target complex.

b. The firing portion of each pass is divided into five regions. The regions are established for the purpose of associating aircraft vulnerability to antiaircraft fire during a specific engagement. The vulnerability of the aircraft during the attack can be determined in each region by exercising the model HOVARM. The calculated probability that the aircraft is lost at a specific range is introduced for each region of each pass.

c. Subregions are established within the above regions during the casualty assessment phase of the pass. Boundaries for subregions are created by the graph of one of the following events:

(1) A change in troop posture occurs.

(2) The firing of one weapon system ends and the firing of another weapon system begins.

(3) The aircraft breaks away from the target.

(4) A region boundary is reached.

d. The number of rounds to be fired from each weapon system and the sequence of the firing are input for each pass. However, the program automatically fires two rockets just prior to the break on each pass for suppressive purposes. Weapon system five is the only system which is allowed to fire in region five. This weapon system is normally a machine gun.

e. Delivery errors associated with the weapon system and ballistic error associated with the munitions form part of the input set of errors. The delivery errors consist of target location errors, target centroid errors, and weapon system sighting errors. The ballistic error is defined through the dispersion angle for the weapon system.

f. The aimpoint for the weapon systems is taken as the center of target number one or a point offset from this center. A separate offset is permitted for each pair of passes; that is, the wingman uses the same aimpoint as the leader on the preceeding pass. The offsets are a function of the weapon system.

5. MODEL LIMITS. Figure IV-9 defines the limits of the HOVER model as determined by the computer program. Some or all of those limits can be changed but require program modification.

6. DYNAMIC LOGIC FLOW

a. The HOVER methodology is structured such that the target array, the airborne weapon systems and proposed expenditures, and other factors which define the parameters affecting the engagement are read in from formatted punched cards and the engagement begins.

b. The model is composed of a main program and nine interfacing subroutines or functions. The purpose of the main program is to read input values to be used, to set certain values, to list the input items as the first items of output and to call in-turn other subroutines. Figure IV-10 provides an overall view of the decision and information flow.

c. The first subroutine called during the simulation is TGT. The function of this subroutine is to dimension and array targets and to create elements or sample points within the targets upon which effects are determined. Up to five targets can be created and input as circular or rectangular. Targets cannot be mixed. Up to 400 elements or sample points are distributed uniformly or randomly, and spacing of elements is specified.

d. The second subroutine called during the simulation is DELIVE. This subroutine computes the percentage coverage of the targets by the areas of effects of the weapons fired.

(1) The center of the effects area is located on the coordinate system. The aimpoint is the center of target number one or a point offset from this center. A separate offset is permitted for each pair of passes, that is, the wingman uses the same aimpoint as the leader on the preceeding pass. The actual center of the effects pattern is normally displaced from the aimpoint as a result of the delivery and ballistics errors.

(2) The specific location of the center of the effects pattern is computed for each weapon system and each offset. For each range point, weapon system, and offset combination, the location of each element of each target is then compared to the boundaries of the effects pattern to determine if it lies within the pattern. The preceeding procedure is repeated, each time selecting a random number to apply to the delivery and ballistic errors. When the desired number of replications are complete, the number of target elements of each target and the total of all targets that are contained in the effects patterns of each range point, weapon system, and offset combination are divided by the possible number of points. This yields the fraction of each target and of all targets covered by the pattern for each combination of range points, weapon systems, and offset.

e. The third subroutine called during the simulation is PASSES. This subroutine utilizes input range points to create five regions. A region may be described as merely a subdivision of a pass. It is created for the single purpose of associating aircraft vulnerability to anti-aircraft fire with a specific attack. The vulnerability of the aircraft in attack is determined in each region by exercising the model HOVARM. The calculated probability that the aircraft is lost at a specific range in a specific antiaircraft environment is introduced for each created region.

f. The fourth subroutine called during the simulation is AMMODI. The function of this subroutine is the distribution of ammunition. Ammunition on board an attacking aircraft not vulnerable to antiaircraft fire can be distributed into two categories: ammunition that is expended, and ammunition that is returned to home base with the aircraft. AMMODI is structured to allow the introduction of a probability that the aircraft is lost during each region of each pass of a target attack. This probability necessitates the creation of other categories of ammunition distribution to include ammunition that is lost as a result of the loss of the aircraft to enemy fire. The distribution of ammunition is computed in each region and summed over the number of regions and passes for each weapon system. Ammunition is distributed into four categories: ammunition fired and delivered on target, ammunition fired and lost, ammunition lost when the aircraft is lost, and ammunition returned unexpended.

g. The fifth subroutine called during the simulation is CASUAL. This subroutine computes the fractional casualties in each target from each weapon system in each region for each pass as well as totals and subtotals of these.

(1) Due to the changes in troop posture the submodel maintains surveillance of elapsed time beginning with the start of the first pass.

(2) The submodel utilizes the firing regions created in the PASSES submodel as well as the rounds fired. The regions are divided into subregions for computational purposes when

(a) a change occurs in target troop posture;

(b) the firing of a weapon system terminates; or

(c) a range point is reached.

As the model steps through regions it calculates which of these events will occur next. The number of rounds fired in the subregion is in direct proportion to the number of rounds in the firing region and the length of the subregion and in inverse proportion to the length of the firing region. The model then calls upon submodel COMBIN to utilize the current troop posture, the number of rounds of a specific weapon system fired, and the mid-point of the subregion to compute the fractional casualties in the subregion.

(3) Time is incremented by the time required to fly the subregion at optimum speed for firing the weapon system used in each subregion. When an attacking aircraft flies portions of a pass without firing any weapon system, time is incremented by the time required to fly that distance at the optimum speed for the last weapon system fired.

(4) Finally, this submodel combines the fractional casualties for each subregion into accumulative casualties for the region, the pass and the mission from each weapon system individually and all combined. This is done for each target and the total of all targets.

h. The sixth subroutine called during the simulation is COMBIN. This submodel computes the fractional casualties from a weapon system in a subregion for the targets individually and in total, and is called by subroutine CASUAL. Subroutine COMBIN, in turn, interfaces with subroutine EFFECT to produce the fractional casualties. It accomplishes three specific functions: the computation of fractional coverage at the midpoint of the subregions, the computation of effects area dimensions at an interpolated range for input into subroutine EFFECT, and the computation of expected casualties in each subregion.

i. The seventh subroutine called during the simulation is EFFECT. This submodel is called by subroutine COMBIN and is used to compute the fractional casualties within a given subregion. The effects areas of all weapon systems fired in the sebregion are integrated together to determine the expected fractional casualty coverage.

j. Submodels RANDOM and XNOIN are called upon at various places in the previous submodels to generate either a uniformly or normally distributed random number.

7. PRINCIPAL ASSUMPTIONS. The principal assumptions made in the HOVER model are listed in the following paragraphs.

a. The armed helicopter is not vulnerable to small arms ground fire.

b. The armed helicopter never aborts a firing pass.

c. The pass flown by the wingship is always identical to the preceeding pass made by the lead aircraft.

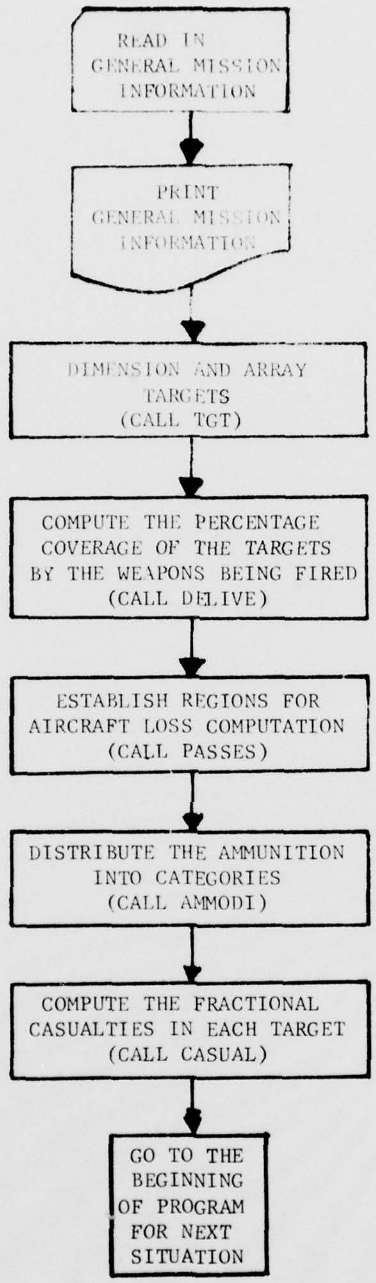
d. The weapon systems on the aircraft never malfunction.

e. The targets and elements within each target are stationary during the entire mission

Figure IV-9--Limitations of HOVER

	Minimum	Maximum
Number of targets in the target complex	1	5
Number of elements in the target complex	1	400
Number of passes the aircraft make at the target complex	2	6
Number of weapon systems on the aircraft	1	5
Number of ground personnel posture changes during the mission	1	10

Figure IV-10--HOVER Flow Chart



APPENDIX V

AIR DEFENSE REQUIREMENTS

1. INTRODUCTION. Input action[5] from the Air Defense Agency (now part of the Air Defense School) in support of this study provided the combat rates for the air defense weapons. An adjustment to the rates provided by the input action is made for the VULCAN to reflect the ground support role requirement. Ground support expenditures are derived from the Infantry Combat Model and the Tank Antitank Model. Certain recomputations were performed on the above input action to correct mathematical deficiencies and to introduce an updated air threat.

2. GENERAL METHODOLOGY. The methodology used to compute nonnuclear ammunition requirements in this study is essentially the same as that used in previous nonnuclear ammunition combat rate studies including the following refinements.

a. This study utilized an attrition factor to account for a reduction of the air threat due to non-Army air defense means.

b. Limited redistribution of ammunition in FY 79 was considered for the Nike Hercules and Hawk systems. Any significant, timely large scale redistribution would necessitate air transport, the availability of which is questionable during the FY 79 time frame.

c. The single-shot kill probabilities for the Hawk and Hercules systems were refined based upon best available current firing date.

d. A "Q" factor was introduced to account for logistical losses.

3. AMMUNITION REQUIREMENTS. The basic equation used to determine

---

[5] Letter, CDCSAG-AG3, Subject: Input Action in Support of Nonnuclear Ammunition Combat Rates, (S), 16 August 1972, and Letter, CDCAD-PC, Subject: Input Action in Support of Nonnuclear Ammunition Combat Rates (S), 26 October 1972.

nonnuclear Air Defense ammunition quantity (N) is:

$$N = Q \cdot \frac{T}{SSKP}$$

a. Q Factor. Ammunition requirements for ADA systems are based primarily on the threat opposing that system (T) and the system single shot kill probability (SSKP). To add realism to the ammunition requirement, consideration has been given to the following factors to which decimal values have been assigned based on previous air defense studies and experience.

(1) Inefficiency of redistribution of missiles and the logistic system. This factor also takes into account losses which may take place during the movement of munitions from CONUS to the theater of operation. .1

(2) Ammunition losses due to hostile actions. 1.0

(3) Inefficiency in the control and coordination systems associated with Air Defense Artillery. .1

The "Q" factor is, thus, considered to equal 1 plus the sum of the decimal values of the above mentioned factors.

b. Threat Mission Assignment. The number of targets allocated to each ADA weapon system was determined using the following procedure:

(1) The Intelligence Threat Analysis Detachment (ITAD) provided air threat to each theater of interest. Additionally, ITAD made provisions for attrition to the threat by other non-army air defense means (interceptors, counter-air, and air base strikes), and provided an estimate of the direct threat to the ADA systems[6].

(2) An allocation of the direct threat to ADA was made to each of the ADA systems based on threat capabilities, employment, deployment, and force levels.

---

[6] Letter, CDCSAG-AG3, Subject: ADA Input Action in Support of Nonnuclear Ammunition Combat Rates for the FY 75/79 Time Frame (S), 15 January 1973.

c. Single Shot Kill Probability (SSKP). The air threat facing each ADA system was broken down into two groups: tactical aircraft and bombers. These groups combine aircraft having similar flight profiles and radar/visual characteristics. A SSKP was then derived for each system against both of these two target groups. A further refinement in the case of two systems (Hawk and Vulcan) was necessary to reflect the firing doctrine which was assumed to be used. That is, both these systems will fire more than a single round at each aircraft; therefore, the SSKP will be a joint kill probability.

d. Ammunition Requirement. The ammunition requirement for the Redeye was computed in a slightly different manner. Past studies have established a basic load of M missiles per Redeye team. Additionally, in a massed air strike type engagement, only approximately one-fifth of the teams in a division would be in a position to engage the strike. Therefore, the following equation was used to determine the number missiles (N) required for this system:

$$N = 1/5 \left(Q \cdot \frac{T}{SSKP}\right) + 4/5 (M) (W)$$

Where W is the average weapon density for the theater under consideration.

4. PRINCIPAL ASSUMPTIONS. The following assumptions were made in the preparation of the air defense weapon rates:

a. The results of prior air defense studies are applicable to the scenario and time frame used in this study.

b. The helicopter and transport aircraft which are part of the overall threat, will not be a direct threat to ADA.

c. A portion of the air threat will be attrited by non-Army air defense systems.

d. Large scale redistribution of ammunition for the Nike Hercules and Hawk systems is not practical during the time period the air threat exists.

APPENDIX VI

TARGET ACQUISITION MODEL (TAM)

1. PURPOSE. The purpose of this appendix is to describe the methodology used by TAM in producing acquired target lists for use by the Fire Planning Model (FPM). The model is used to sense both Red and Blue arrays and produces target lists for engagement by both Red and Blue artillery batteries.

2. METHODOLOGY.

a. Map Analysis. Exercise of the methodology begins with a map analysis of the opposing forces which must be laid out by unit in positions which they would occupy in a stylized situation. From this array, a target list of all forces eligible for detection must be prepared and resolved to platoon or higher level. Each line on the target list refers to one target unit and completely defines that unit for the model. Data for this definition includes:

(1) Unit identification.

(2) Location (6 digit coordinates).

(3) Target category code.[7]

(4) Distance from the FEBA.

(5) Mobility code.

(6) Environment codes.

(7) Number of troops.

(8) Identification of the principal type of equipment that the unit employs (trucks, tanks and APC's, artillery pieces, missiles, mortars).

(9) Number of such elements of equipment.

(10) Identification and quantity of all major items of equipment (as desired by the user), and

(11) Target radius code.

---

[7] See Basic Data, Annex E.

b. Sensor-Target Confrontation. The model addresses each line of the target list individually. This confrontation between the sensor systems and each enemy target occurs only once during a 6-hour stylized period. At that time, the model makes provisions for simulating and recording all relevant history about that individual target and the sensor system. When the model focuses on a given target, it seeks to answer the question: "Will this target be acquired during this 6-hour period?" This determination is made as follows.

c. Individual Target Acquisition. The acquisition of an individual target is a multistep process. This process starts with distributing the sensors across the FEBA and, for each type sensor combining the probability of line of sight, probability of the sensor covering the target, and, finally, the probability that the target is detected by the sensor given line of sight and coverage. Once the probability of acquisition has been determined, the inclusion of a specific target in the acquired target list is based upon a random number process.

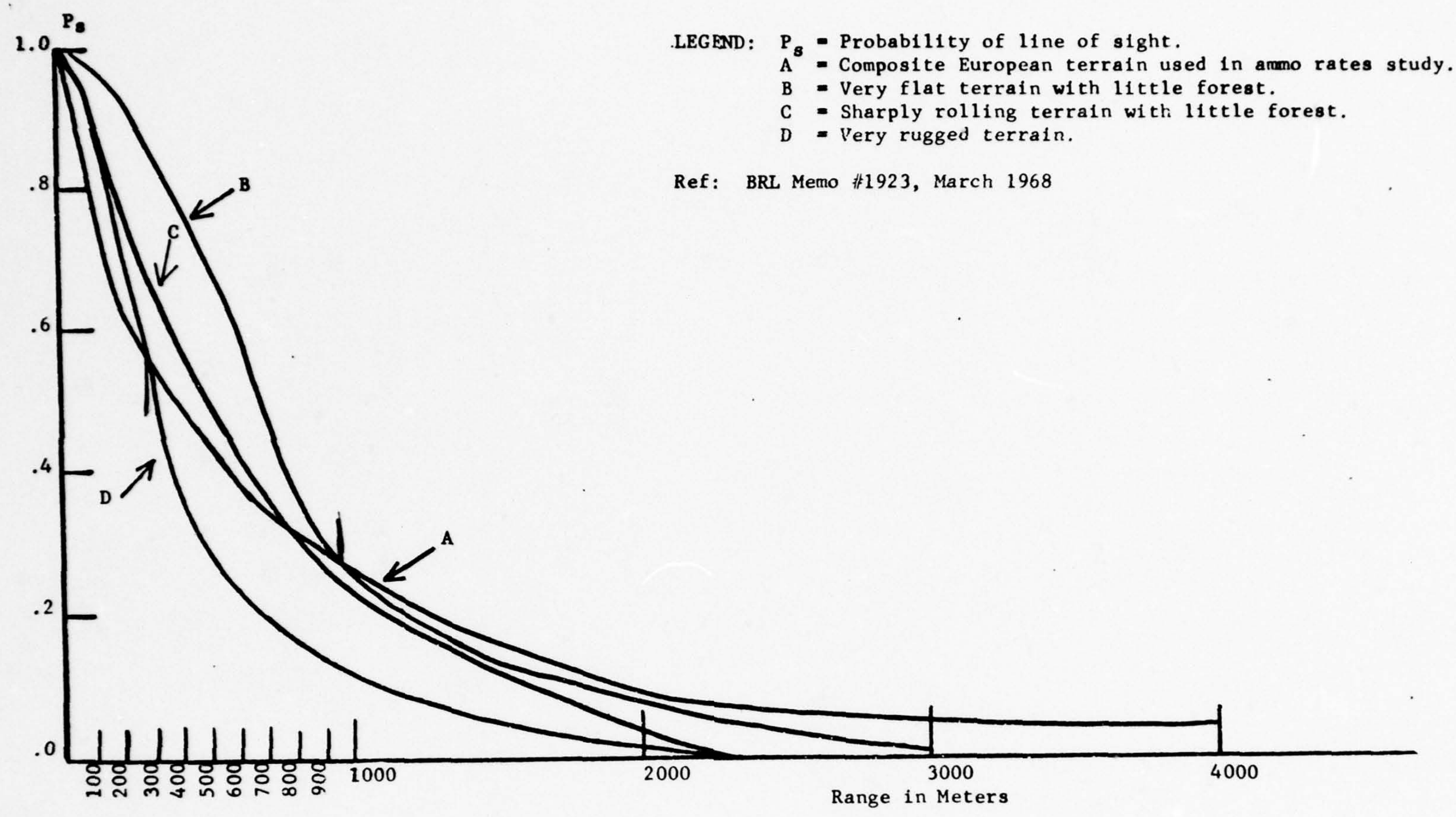
d. Line of Sight Probabilities. The probability of line of sight for a ground-based sensor is shown in Figure IV-11 for Europe. The curves identified as B, C, and D are for three different terrains and are taken from the Legal Mix IV study[8]. The curves used in the ammo rates target acquisition model are taken from the TARS-75[9] study and are believed to be a reasonable composite of the three curves taken from Legal Mix IV. Additional curves relating line of sight, probability, and range are used for airborne sensors. Furthermore, a set of curves for both ground and airborne sensors characteristic of Korea is used in developing ammunition rates for the Pacific theater.

---

[8] Optimum Mix of Artillery Units 1975-80 (U) (Short Title: Legal Mix IV), US Army Combat Developments Command, Field Artillery Agency, June 1972, SECRET.

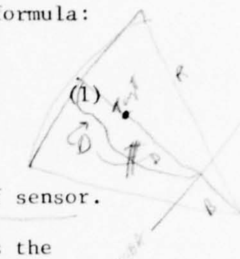
[9] Tactical Reconnaissance and Surveillance (Short Title: TARS-75), US Army Combat Developments Command, Institute of Combined Arms and Support, July 67, SECRET.

Figure IV-[illegible] -- Line of Sight Analysis - Europe Ground-Based Sensor



e. <u>Coverage for Stationary Sensors</u>. The expectation of coverage for stationary sensors is computed from the following formula:

$$E_c = \frac{2 * NSEN * [R^2 - (D + B)^2]^{1/2}}{WFEBA} \qquad (1)$$



where:

E_c is the expectation of coverage by a given type of sensor. When E_c is less than or equal to 1 from equation (1), it becomes the coverage probability directly. The treatment of coverage probability when E_c as computed from equation (1) is greater than 1 is discussed later in this section of the appendix. NSEN is the number of sensors of the type whose coverage expectation is desired. It will be noted that a uniform distribution of sensors across the FEBA is tacitly assumed.

R is the detection range of the sensor.

B is the distance the sensor is set back from the FEBA.

D is the target distance from the FEBA. no !!

WFEBA is the width of the FEBA.

f. <u>Coverage for Moving Sensors</u>. The probability of coverage for moving sensors is computed from the following formula:

$$P_c = \frac{RATE * TIME * RANGE * NSEN}{AREA} \qquad (2)$$

where:

P_c is coverage probability for moving sensor.

RATE is the average movement rate for the sensor within TIME.

TIME is the number of hours within the stylized 6-hour period that the sensor is moving.

NSEN is the number of sensors being considered.

AREA is the total area within which the moving sensors are operating.

RANGE is the maximum distance at which the sensor has a detection probability greater than zero.

g. Target Detection Probability. The probability of target detection by detecting vehicles contained within the target is:

$$P_D = 1 - (1 - P_{dv})^{JVEH} \qquad (3)$$

The probability of detecting the target by detecting personnel contained within the target is computed by:

$$P_D = 1 - (1 - P_{dp})^{JPER} \qquad (4)$$

same??

where:

P_D is probability of target detection.

JVEH is the number of vehicles contained within the target.

P_{dv} is probability of detecting an individual vehicle.

JPER is the number of personnel within the target.

P_{dp} is the probability of detecting a single person.

vehicle or personnel

It will be noted that a target is considered detected if at least one element is detected. Later discussion will show that this detected element can be a vehicle or an individual person.

h. Target Acquisition Probability. The probability of acquiring the target, P_A, is the product of the probability of line of sight, P_L, taken from a curve similar to Figure IV-11 given the range from target to sensor, the probability of coverage, P_C, taken from equation (1) or (2) as appropriate, and finally the probability of detection from either equation (3) and (4). The numerical value of the probability of acquiring the target is computed from the following formula:

$$P_A = P_C * P_L * P_D \qquad (5)$$

where all the quantities in equation (5) have been defined in the preceding paragraphs.

i. Target Acquisition. The procedure for determining if a target is acquired and, hence, is added to the acquired target list is to select a random number from a uniform distribution betwen 0 and 1; if the number selected is less than P_A, the target is included on the

acquired target list. There are certain modifications to this procedure depending upon the numerical values of coverage computed by equation (1) or (2) and the use of the detection probabilities expressed by equation (3) or (4). The procedure will be clarified with the aid of some illustrations.

j. Illustrative Example of Target Acquisition - Case 1. First, assume that equation (1) produces a number less than 1 which can be taken as the coverage probability. A numerical value for P_A is computed from equation (5) utilizing a value of the detection probability, P_d, computed from equation (3). In other words the acquisition of a target is first considered through the detection of vehicles in the target. The random number procedure is followed; if the target is acquired, it is added to the acquired target list and the next target is considered. However, if the random number is greater than P_A or none of the vehicles in the target are detected the procedure is repeated with the value of P_D computed from equation (4). Thus, target acquisition is first attempted through detection of vehicles and if acquired the procedure stops. However, if acquisition fails through vehicle detection, the use of personnel detection is used and if the target is acquired through personnel detection it is added to the acquired target list.

k. Illustrative Example of Target Acquisition - Case 2. A second case is where the numerical value of equation (1) is greater than 1.0 indicating that the target is covered by more than one sensor of the sensor type being considered. For example, if the numerical value of equation (1) was 1.6 the random number procedure described above would be followed but first with P_C in equation (5) set equal to one and P_D as computed for vehicles. If no acquisition occurs the procedure is repeated but with P_C now equal to 0.6 in equation (5). If an acquisition does not result from this second step the random number procedure is continued but now with P_D computed for personnel from equation (4).

?

l. Estimating the Category of the Target. The target acquisition model recognizes 16 target categories of which four are dominated by armored vehicles while the remaining 12 are either artillery batteries or targets whose elements are primarily personnel. Of the four target categories dominated by armor vehicles two contain armored vehicles only, hence it is assumed that these targets could not be mistaken for personnel targets. The remaining two targets which are primarily armor do contain some personnel and it is possible that a target in these categories could be acquired on the basis of the detection of personnel. If this occurs then the targets are taken as personnel targets (i.e., category one targets) for purposes of weapon selection and anti-personnel ammunition is fired at these misidentified targets. Casualty assessment is, of course, based upon ground truth and not estimates.

m. Estimating the Radius of the Target. Let the probability that the sensor detects a single element within the target be P_D. If the target has N elements then the estimate of the number of elements detected is obtained by drawing a random binomial variate out of $B(N, P_D)$. For purposes of illustration assume that this procedure identifies S elements as being detected. The model now calculates the probability that exactly S elements are detected if the target is platoon sized, company sized, or battalion sized. The target size with the highest probability is taken as the estimate of the size of the detected target. This is easily converted to target radius since for each category of target a radius has been identified for the three target sizes used.

n. Multiple Detection.

(1) The target acquisition model does not provide multiple sweeps of the battle area but rather considers each target on the battle area and determines that it is or is not acquired. This leaves the problem of multiple detection to be resolved.

(2) Multiple detections are introduced into the acquired target list with the aid of the curves of Figure IV-12 which shows the distribution of multiple detection for day and night. These curves are generated from the acquired target list published in the Legal Mix IV report.

(3) Let ITIME (I) be defined as the number of targets detected I times. Thus:

$$\text{ITIME (I)} = \text{DET} * \text{DIST (I)} \tag{6}$$

where:

DET is the number of detections taken from the target acquisition model.

DIST (I) is taken from the ordinate of the curves of Figure IV-12.

I is the number of times the target is detected.

(4) Utilizing equation (6) the number of targets contained in the final acquired target list is:

$$\text{ACQ} = \sum_{I} \text{I} * \text{ITIME (I)} \tag{7}$$

Targets do not appear randomly, but are correlated.

The final acquired target list is developed by randomly shuffling the list of singly detected targets from the target acquisition model and then assigning the first ITIME (1) targets to be acquired once, the next ITIME (2) targets to be acquired twice and so forth. The target list which now contains multiple acquisitions is shuffled randomly again and the order in which the targets now appear is taken as the order within which they are detected.

o. Time Distribution of Targets.

(1) The remaining operation to be performed on the acquired target list is to distribute the target in time so that the time "bunching" of targets in the tactical operations center can be simulated. The procedure for bunching targets utilizes the curves presented in

Figure IV-12-(U) Distribution of Multiple Acquisitions Over Six Hour Periods From Legal Mix IV (U)

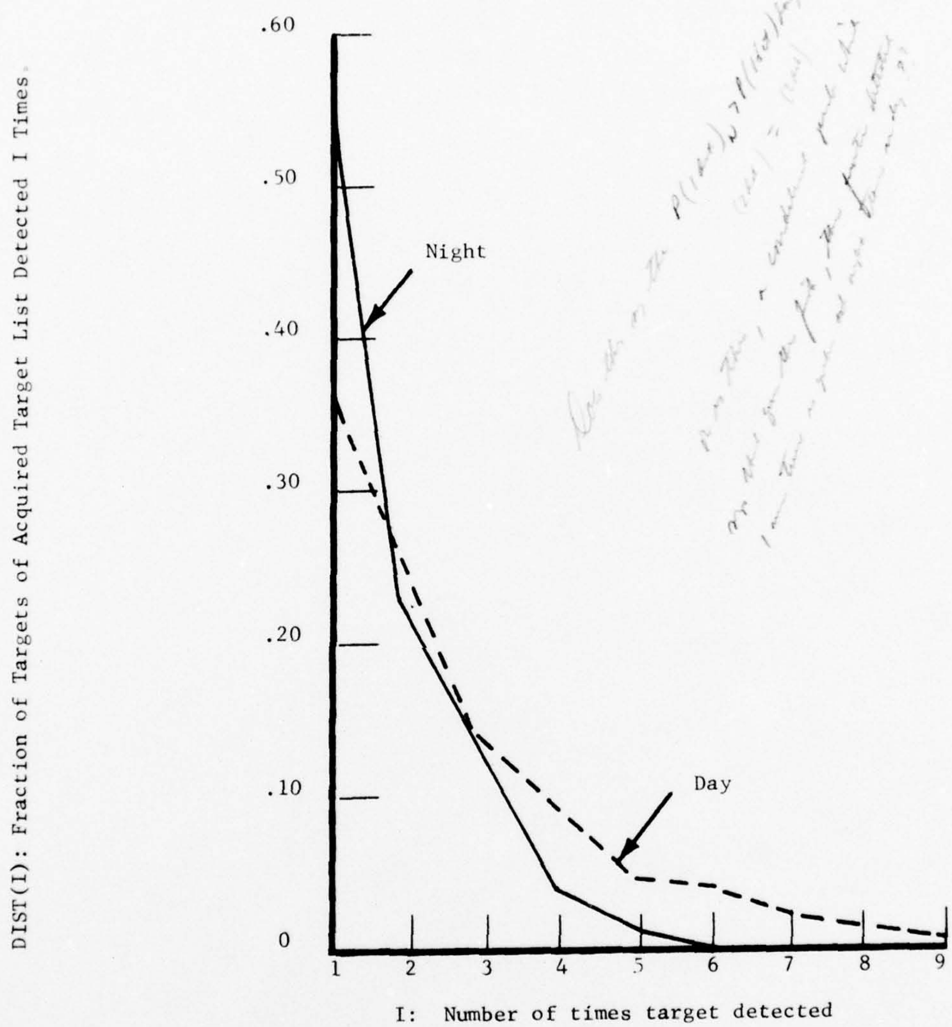


Figure IV-13 which again are generated from information published in the Legal Mix IV report.

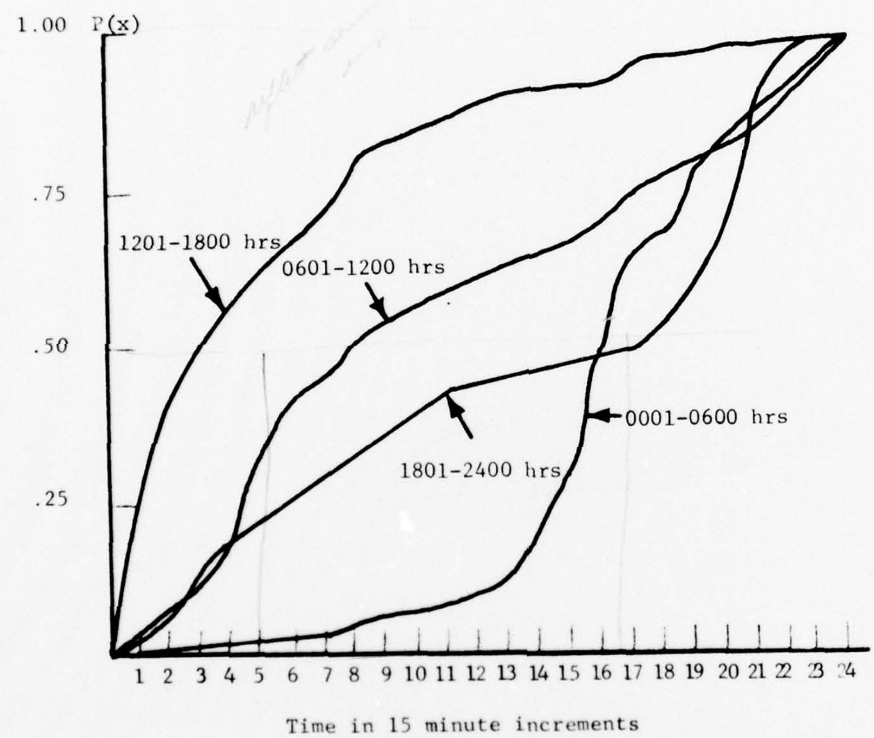
(2) Figure IV-13 shows the cumulative distribution of target acquisitions as a function of time. In this case time is for a 6-hour per iod and is divided into 24 fifteen-minute segments. Targets from the acquired target list are assigned to each time segment in accordance with the curves of Figure IV-13. It may be seen from this figure that a distribution curve corresponding to each of the four 6-hour periods used in ammo rates is presented. Once the number of targets for a 15-minute interval has been determined they are distributed within the interval by a random number procedure which assumes the uniform random distribution of acquisition times within the 15-minute interval.

p. Model Replication. To preclude the possibility that the list of targets acquired by the model is not representative of average values the model is replicated a minimum of ten times. After each replication, the model establishes if the average values for NTNK the number of armor targets acquired and NINF the number of non-armor targets acquired are both within 10 percent of their averages computed on the basis of all previous runs. If so, the last replication is run for record and the final output is prepared. If not, model replication continues.

3. ASSUMPTIONS. The following assumptions are inherent in the methodology employed in TAM.

a. Because the exercise of the methodology addresses sensors against the enemy or friendly array on a nominal basis only once during a 6-hour stylized period, the analysis is basically static. The methodology is thus dependent on outside data for determination of multiple acquisitions of the same target and on the distribution of

Figure IV-13--Time Distribution of Acquisitions (Legal-Mix)



acquisitions over time. The data used to generate multiple acquisitions and to distribute acquisitions over time has been obtained by analysis of the Legal Mix IV study, and this analysis is documented in the Non-Nuclear Ammunition Combat Rate Methodology Improvement Program (PHASE I) study report. Basic data used in this study is contained in volume V.

b. The methodology assumes a linear FEBA and does not locate both sensor and target for detection purposes. The sensor is assumed to be located at a reasonable vantage point, and all sensors of a given type are assumed to be deployed at fixed intervals across the front and at a given constant distance from the FEBA. Targets are described by their distance from the actual FEBA as played in the map array, and the distance from target to sensor is played as the sum of this distance and the setback of the sensor.

c. The methodology does not play changes in location of targets over a given 6-hour stylized period. The description of a target as being in the open and moving, for example, is taken to mean that it is open and moving at that instant of time when it is confronted by the sensor systems.

d. The methodology assumes that no significant attrition of sensors occurs within a given 6-hour stylized period. A stylized period is defined in terms of full strength forces; and the effects of attrition of acquisition capability are played in the exercise of the Theater Rates Model, not in the Target Acquisition Model.

- Isn't target acquisition dependent on posture??
- How does attrition (blue & red) affect detection??

From this routine you get Ave EXP portion of smaller for all possible (?) artillery situations.

APPENDIX VII

CASUALTY ASSESSMENT MODEL (CAM)

1. PURPOSE. The purpose of this appendix is to describe the methodology used by CAM in producing artillery effects data for use in the Fire Planning Model and in the Infantry Combat and Tank/Antitank Models. The outputs of CAM are used to determine preferred weapons lists, preferred rounds list, battery and volley requirements, and effects obtained, used by the Fire Planning Model in the allocation of artillery and other indirect fire weapon resources to targets acquired. The general logic flow of the methodology is presented in Figure IV-14.

2. METHODOLOGY

a. General. This model simulates the firing of artillery weapons at targets which can assume up to three postures simultaneously and whose overall posture can be changed once during the fire mission. The model uses a lethal area methodology and is designed primarily to simulate improved conventional munitions (ICM). It can be used also to approximate the firing of HE type munitions by proper set-up of the input data.

b. Situations. The methodology used in the model is applied to all possible artillery situations. A situation is defined as a specific set of criteria which uniquely defines the relationship between the target and the firing battery (batteries). It is defined in terms of:

(1) Type weapon system firing.

(2) Type munition being employed.

(3) Accuracy of the weapon system.

(4) Lethality of the munitions vis-a-vis the target.

(5) Number of batteries firing.

(6) Number of tubes per battery.

(7) Sheaf of the firing batteries.

(8) Type target being engaged.

(9) Description of posture of target elements.

(10) Description of changes of posture of target elements.

(11) Target size.

(12) Target environment.

Thus, a situation definition might be, for example: three batteries of 155-mm howitzer firing unadjusted, using HE (M107) ammunition, firing from offset parallel sheaves, at a target in the open with 80 percent of troops standing, 20 percent prone in a 50-meter radius area. By the time of the second volley, all troops are prone. The model is used to fire and assess effects for every Red and Blue type artillery system, using every type munition played, at all possible combinations of target category,[10] target size (50-meter, 100-meter, ... 350-meter radius) and target environment (open, woods), for up to four batteries firing.

c. Simulation Methodology. For each situation defined, the model replicates the following procedures 50 times.

(1) One hundred (target element sampling points are distributed randomly within the target area which is either circular or rectangular. Distribution is in such a manner that the probability of two sub-areas of equal size containing the same number of elements, is equal; i.e., if target area is X and X_1 and X_2 are areas of equal size less than X, and if P(Z:N) is the probability that exactly N $\leq$ 100 target elements fall in an area of size Z, then: $P(X_1 :N) = P(X_2 :N)$.

(2) Target category specifies that A^I, B^I, and C^I% of the target elements will be in postures 1, 2, and 3, respectively, in the initial posture, and that A^F, B^F, and C^F% will be in postures 1, 2, and 3, respectively, in the final posture. During those volleys in which the target elements are in initial postures, elements 1 to A^I will be

[10] See Basic Data, Annex D.

in posture 1, elements $A^I + 1$ to $A^I + B^I$ will be in posture 2 and elements $A^I + B^I + 1$ to 100 will be in posture 3. The procedure for final posture is analogous to the above procedure[11].

(3) If the number of batteries firing is NBATS, the number of tubes per battery is NTUBES and the number of volleys fired is NVOLS, the model calculates impact coordinates for NROUND rounds where:

NROUND = NBATS * NTUBES * NVOLS

The model generates target element locations in cartesian coordinates and assumes that the base tube in each battery is aimed at the origin. Tube 1 in each battery is considered to be the base tube. The following perturbations are then made for each round impact.

(a) <u>Sheaf Effect</u>. If the battery is firing a converging sheaf, no corrections are made to impact coordinates (set initially at the origin). If the battery is firing a parallel sheaf, the impact of each round is a mirror image of the tube positions within the battery and the round from the base tube impacts at the origin.

(b) <u>Centroid Effect</u>. A random centroid error is drawn in such a manner that there is equal likelihood that the error is greater than or less than 0.707 of the target radius. That is, the error made by the sensor in locating the center of the target is considered to be distributed in such a manner that 50 percent of the time it will not shift the aimpoint further away from the origin than the radius of a concentric circle (or the dimensions of a concentric rectangle) having half the area of the target. In the case of a circular target with radius R, the random centroid error for the target center will be given in polar coordinates by:

---

[11]Postures 1, 2, and 3 can, but need not be, standing, prone, and foxhole, respectively.

Angle = $V_{1} * 2\pi$ and

Radius = $\sqrt{V_2} * R$ where

V_1, V_2 are random numbers out of R(0,1). In the case of a rectangular target with dimensions W and D, the random centroid error will be given in cartesian coordinates by:

$X = V_1 * .8493 * \cancel{CEP}\ W$ and

$Y = V_2 * .8493 * \cancel{CEP}\ D$

where V_1, V_2 are random numbers out of N(0,1).

(d) Battery Effect. A random battery error is drawn out of a normal distribution such that the error in the range (Y direction) is distributed according to the probable error (PE) in range, and the error in deflection (X direction) is distributed according to the probable error in deflection. The variates drawn are in cartesian space and are given by: ? N(0,1) with .67 area

$X = V_1 * \overset{1.826}{\cancel{1.4296}} *$ PE deflection and,

$Y = V_2 * \cancel{1.4790 *}$ PE range, where:

V_1, V_2, are random numbers out of N(0,1). Each battery firing is given a distinct battery error.

(e) Piece Effect. A random piece error is drawn for each round fired out of a truncated bi-normal distribution having range and deflection mean point of impact (MPI) equal to piece error range and deflection MPI, respectively. The cartesian variates X and Y are drawn analogously to those described in the battery effect section above.

(4) Individual round impact coordinates are obtained from the above perturbations as follows:

(a) Each round impact is perturbed to account for the sheaf effect, volley by volley.

(b) Each round impact is perturbed to account for the centroid effect, the same perturbation being applied to every round.

(c) Each round is perturbed to account for the sensor effect, the same perturbation being applied to every round.

(d) Each round is perturbed to account for the battery effect, the same perturbation being applied to every round fired by the same battery.

(e) Each round is perturbed to account for the piece effect, a different perturbation being applied to every round.

(5) Casualties for the mission are assessed in the following manner: Let:

(a) PCAS (I, J) be the probability that element I is a casualty on the Jth volley, given that he has survived all previous volleys.

(b) PATRA be the pattern radius of the submunitions of a given round.

(c) LETHA (K) be the lethal area of one submunition against a target element in posture (K). =1,2,3

(d) K be the posture of target element I.

(e) RELY be the inflight reliability of a submunition.

(f) TOTAL be the number of rounds in a volley that are within a distance PATRA of target element I.

(g) NSUBR be the number of submunitions in a round.

Then PCAS (I, J) $\widetilde{=}$ 1 - e $^{-X}$, where: → ratio of lethal area / total pro[illegible] lethal area

$$X = \text{TOTAL} * \text{NSUBR} * \text{RELY} * \text{LETHA (K)} / (\pi * \text{PATRA}^2)$$

But given PCAS (I, J): I = 1, N

J = 1, NVOLS

where: N = number of target elements (Sampling points) and

NVOLS = number of volleys fired

$$\text{ECAS (1)} = \sum_{I=1}^{N} \text{PCAS (I,1)}$$

why do you check for PCAS(0) ≡ 0

$$\text{ECAS(J)} = \text{ECAS (J-1)} + \sum_{I=1}^{N} \text{PCAS (I,J)} * \sum_{K=1}^{J-1} \text{(1-PCAS(I,K))}$$

for J = 2, ..., NVOLS

casualties from 1st volley

P(Ith elt is casualty on Jth volley) P(not killed prior to Jth volley)

where ECAS(J) is the number of casualties expected by the end of the Jth volley.

(6) The results of the above simulation and calculations are accumulated over a minimum of 30 replications (that is, the fire mission is simulated at least 30 times) and is reported as average expected fraction of casualties (or losses if the target is other than troops) on a volley by volley basis for each volley fired.

3. ASSUMPTIONS. The following assumptions are inherent in the methodology employed by the CAM.

a. The methodology assumes the validity of the lethal area concept of estimating casualty effects. This implies that the expected fraction of casualties (E) from a given round is adequately expressed as the ratio of the lethal area, of the round (L), to the area of effects of the round (A), i.e., that $E \approx L/A$, and also, that end effects are negligible.

b. It is assumed that error in range and deflection are normally distributed.

c. It is assumed that a centroid error exists, and is randomly distributed over the area of the target.

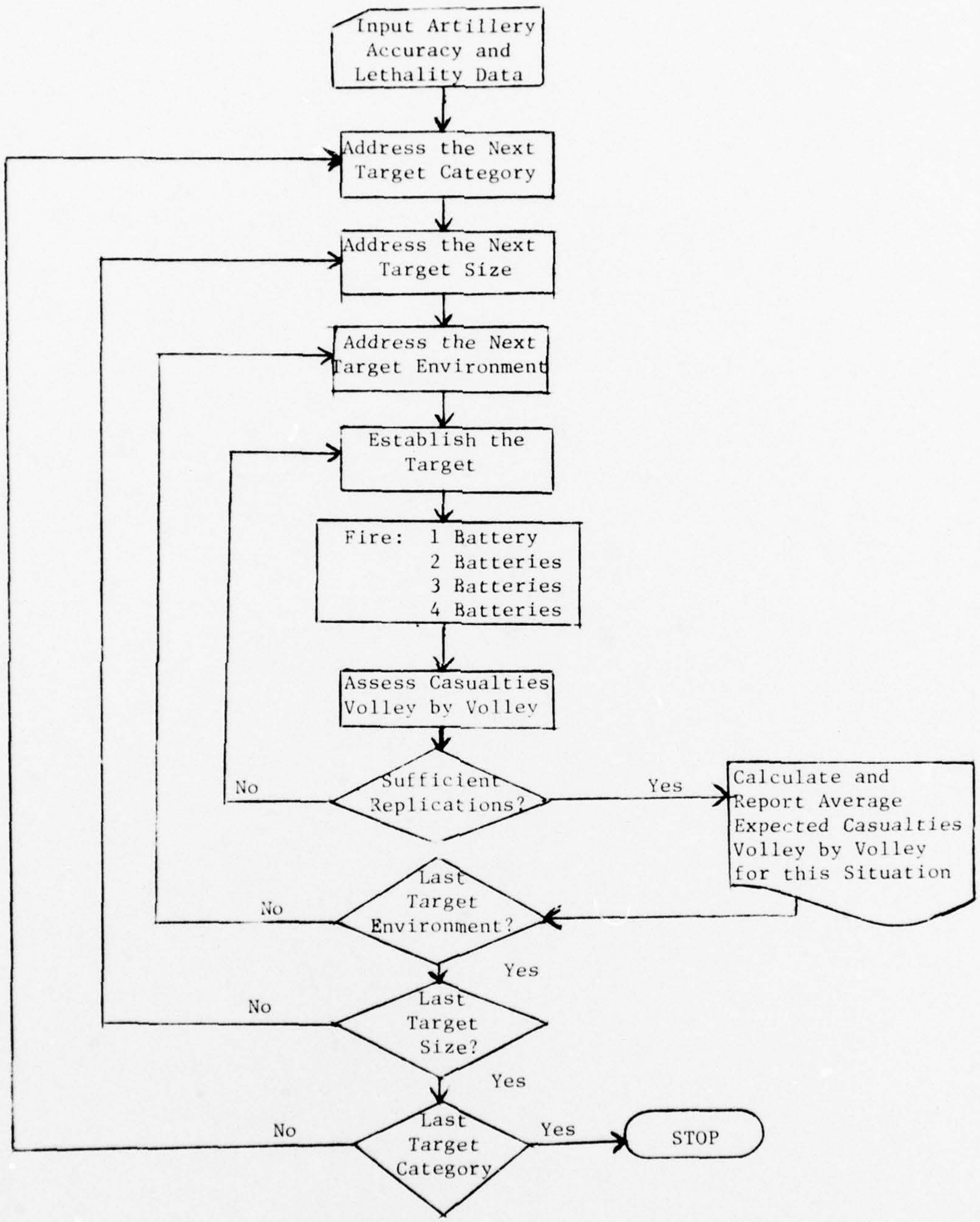
d. It is assumed that all targets can be adequately represented by a circle.

e. It is assumed that the composite error of all sensors is represented by a CEP of 25 meters.

f. It is assumed that all targets can be represented by 100 elements.

obviously
forms smaller
target

Figure IV-14 -- Logical Flow of Casualty Assessment Model



APPENDIX VIII

FIRE PLANNING MODEL

1. (U) PURPOSE. The purpose of this appendix is to describe the methodology used by the Fire Planning Model (FPM) to simulate the engagement of targets with indirect fire weapons. The simulation is used to engage both Red and Blue targets to produce stylized casualty and equipment loss data for use as attrition factors in the Theater Rates Model (TRM) and ammunition expenditures data for use in establishing expected expenditures of ammunition (EEA) and combat consumption rates. The general logic flow of the methodology is shown in Figure IV-15.

2. (U) METHODOLOGY

a. General. The Fire Planning Model (FPM) $\boxed{\text{is}}$ a variable time simulation of the artillery fires initiated by a firing force against a targeted enemy. The model is designed to operate a stylized Blue force against a Red Combined Arms Army (CAA) for a 6-hour period, but can be used to simulate any friendly force with up to 150 batteries, against any enemy force.

How are [illegible] target [illegible] the TRM?

b. Control. The user of this model is in direct control of the variable time clock through the punched card target/event deck. Each card in this deck specifies all of the details about an event to be simulated and the clock time that the event occurs. This deck must, therefore, be sequenced according to increasing clock time. Any number of events can be specified to occur at the same time.

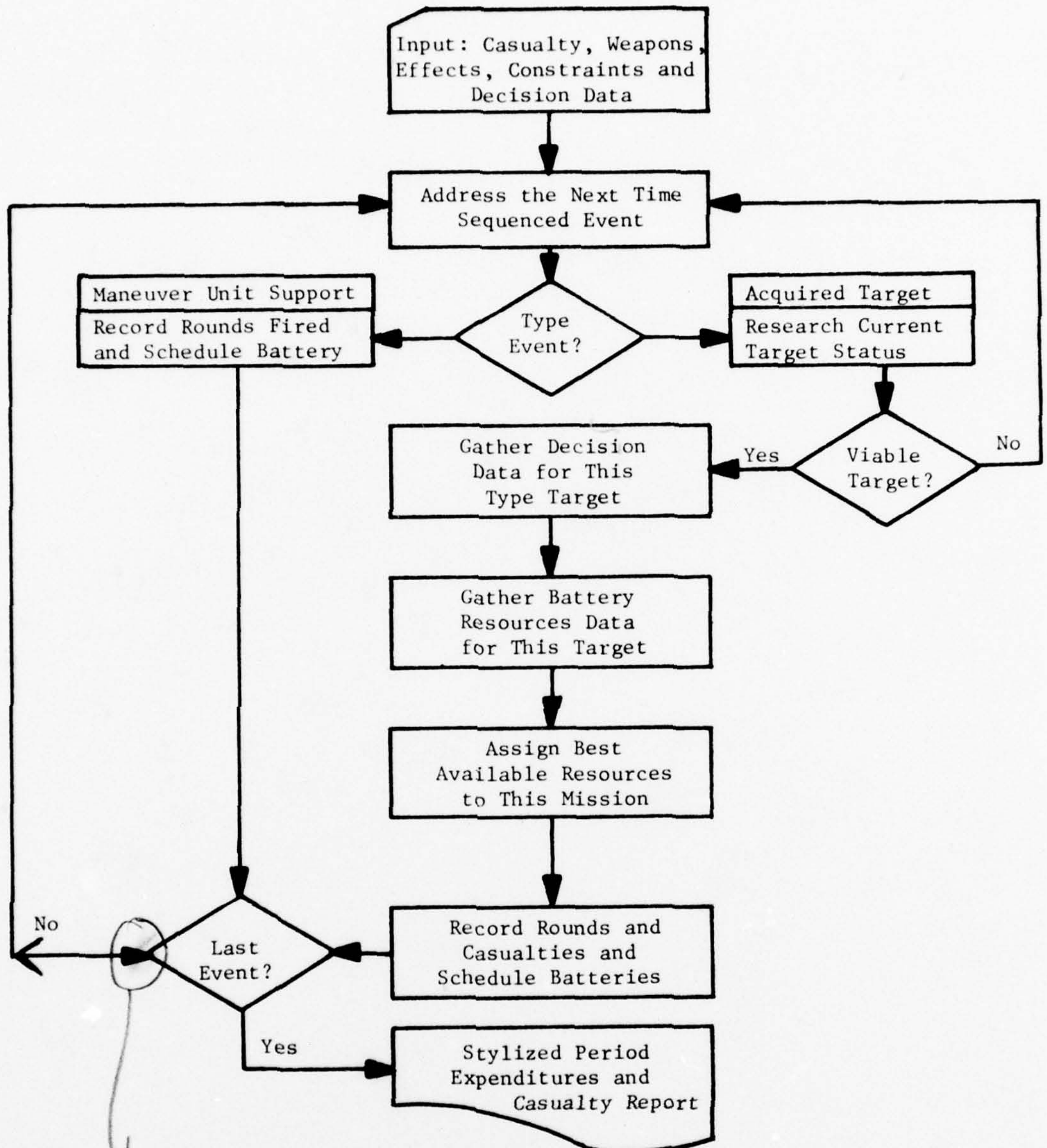
How are the [illegible] (TRM?)

c. Events. The model recognizes two types of events which are processed as follows:

(1) Target Acquisition. The receipt by the fire direction center of a message from a direct support or general support sensor that an enemy target has been located and identified to a sufficient degree to warrant engagement by artillery.

How does the interval of TRM [illegible] [illegible] acquisition?

Figure IV-15--Logic Flow of Fire Planning Model



(2) Maneuver Unit Direct Support. This is a statement that a particular battery is engaged for a specified period of time in dedicated support of a maneuver unit and cannot accept other missions during that time. The model is designed primarily to handle target acquisition, and the duration of actions triggered by such events is a function of the simulation. The maximum time duration of any other is 6 hours per event.

d. Target Data. Each acquired target is described as one of 16 generic types called target categories.[12] Also specified is the environment in which the target is located (open, woods, town, or any combination thereof), the six-digit coordinates of its location, whether it is moving or stationary, what type of specific element was detected (e.g., people, trucks, tanks, or artillery tubes, etc.) and finally the number of troops, tanks, and major items of equipment that the target unit has at full strength (before engagment by any friendly artillery). A target can be acquired any number of times during the simulation; however, if a target has been effectively destroyed by previous artillery missions, it will not be engaged again. Each acquired target event card also must specify whether the detecting sensor operates through direct support (DS) or general support (GS) channels and what target radius has been specified by the sensor.

criteria

from [illegible]?

e. Weapon Data. Input data must describe all basic information relating to each type weapons system that may engage a target. This information requirement includes:

(1) Names and characteristics of each type unit (section, battery) to include:

(a) Number of tubes in a type unit.

(b) Maximum and sustained rates of fire.

(c) Maximum range for unboosted munitions.

---

[12] Seeasic Data, Annex D.

Availability?

(d) Maximum range for boosted munitions.

(e) Maximum volleys which can be fired at a target (based on 4 tons per target constraint).

(2) Type rounds to be used to engage a target as a function of weapon system employed, target category (1-16), target size (50,100,... 350-meter radii), and target environment (open, woods). For each type weapon system, the user may specify up to 10 different type rounds (e.g., for the 155mm howitzer, one might specify type 1=HE, type 2=AP, etc.).

(3) Volleys and number of batteries required to engage a given target and reach the desired kill criteria, assuming that the desired type round is used. This data for each type weapon is a function of target category (1-16) and target size (50,100,...350 meter radii), and target environment (open, woods). The kill criterion is an inherent function of target category and for ammunition rates determination is:

How do you determine target requirement to fire?

(a) Fifty percent of personnel or one minus the fraction of persons in foxholes at the time of last volley, for personnel targets, whichever is the least.

(b) Thirty percent of armored vehicles for armored (hard) targets within 3 kilometers of the FEBA.

** Would assessment model or [illegible] is very sensitive to these criteria.

(c) Ten percent of armored vehicles for armored (hard) targets beyond 3 kilometers of the FEBA.

(4) In no case, however, can rounds required be specified to exceed the following constraints.

(a) No battery is allowed to fire more than 4 tons of rounds at a given target.

(b) No mission is allowed to fire more than 15 tons of rounds at a given target.

(5) Weapon preference data which specifies for each possible combination of the 16 target categories, two terrains (open, woods) and seven target sizes (50,100,...350 meter radii), which type weapon system is the first, second, etc., choice to engage the target. The criterion

(16x2x7

some?

in preference specification in this model for ammunition rates determination has been to order the weapon systems by their ability to reach the kill criteria, and to break ties in favor of the least expensive systems in each situation. Thus, if more than one weapon system type can achieve the desired results, the preference data would rank these systems in order of least cost. Systems not able to achieve the desired assault criterion would be ranked behind those that can, in the order of their effectiveness. ?

(6) Effects data for every possible weapon sytem-target combination. This data includes effects against personnel and tanks for each type weapon system played and is entered in the form of expected casualties (or losses) given that the desired type round is fired and is a function of:

(a) Number of batteries firing (1, 2, 3, or 4).

(b) Target category (1-16).

(c) Target size. (50m, 100,...350m).

(d) Type weapon system firing.

(e) Target environment.

(7) Artillery unit order of battle to include a description, location, and mission of each section or battery engaged in the simulation of the stylized period. Each battery (section) is located by six-digit coordinates and is described as having a mission of either direct support/ direct support reinforcing or general support. really?

f. Simulation Methdology

(1) The simulation proceeds from event to event in the order specified by the input event deck. As a new event is processed, the simulation clock time is stepped to the time specified. At this time, the model makes provisions for all future actions which are required by the occurrence of the event. How are fires [illegible] allocated to each?

(2) If the event stated is other than a target acquisition event, the model seeks out the particular battery mentioned in the event

card and places that battery on the mission firing list. The mission firing list (MFL) is a list of all batteries which were engaged at the time of the previously processed event, and it specifies at what clock time each of these batteries will become available to handle new missions. In the case of final protective fire missions, the model will interrupt batteries on the MFL to fire the mission, as appropriate. At the same time as batteries are placed on the mission firing list for other than acquired target events, it counts the rounds fired, by type round and type weapon, as specified by the event description.

- How do they get generated

(3) If the event stated is an acquired target event, the model determines whether or not the delay involved in firing the mission (administrative delay) is excessive. If the delay is excessive, and if the target is moving, the model causes the target to be lost and skips to the next event.

- How?

(4) If the target is not lost due to excessive delay, the model checks to see if this targeted unit has been engaged previously. If it has been engaged previously, the model determines whether or not the unit is still a viable target. This determination is made based on the percent of troop strength and/or tank strength remaining in the unit after all previous engagements. If the unit has been effectively destroyed by previous fire missions, and if the time since previous engagements is ? less than three hours, the target is not engaged and the model skips to the next event.

(5) If the target is to be engaged, the model updates the simulation clock to the time of this event and then checks each battery on the mission firing list. Those batteries on the MFL whose available times are in the past (with respect to current clock time) are removed from the MFL and placed in a ready status.

(6) After updating the MFL, the model next makes provisions for target identification errors. If the true target category is

described as armored vehicles and if the sensor has detected troops and not armored vehicles, the model converts the target category to a soft target category.

(7) To simulate the human decision process involved in selecting batteries to engage an acquired target, the model next generates a decision matrix. The decision matrix (DM) is initially a matrix with one row for each type weapon which is permitted to fire at a given target, where row 1 refers to the most preferred weapon for this target category, size, environment combination, row 2 refers to the second preferred weapon, etc. Each row of the matrix has five columns. Column 1 stores the weapon type, Column 2 stores the number of volleys required to fire the mission, Column 3 stores the number of batteries (minimum) needed to fire the mission, Column 4 stores the number of batteries available and in range of the target, and Column 5 stores the efficiency of the weapon system in terms of ability to achieve and in range. ? The decision matrix is filled out in three phases. Phase I operations generate all the data in Columns 1, 2, and 3. Figure IV-16 shows a typical decision matrix after phase I. How? what criteria?

Figure IV-16--Typical Decision Matrix--Phase I

DM_I =

Weapon	Volleys	Batteries Required (Min)	Batteries Available (+ in range)	Effective
155	3	2	-	-
8-inch	4	2	-	-
105	12	3	-	-
4.2	24	1	-	-

(8) Phase II operations generate columns 4 and 5 data, in a row-by-row fashion, until the matrix is complete or until stopping criteria have been reached. Phase II operations involve checking all batteries in the simulation, seeing if they are (1) available for a mission and determining (2) if they are in range. All batteries capable of engaging

the target are placed on a candidate list, and summary information is placed in the decision matrix. Data generation in phase II stops before the matrix is complete if one of the following conditions exists:

(a) The number of batteries available in a row is equal to or greater than the batteries required.

(b) The casualties that can be achieved by the available batteries are at least 90 percent of the kill criteria for the target as shown in the effectiveness column.

Effectiveness = ability to achieve kill criteria

Otherwise, the entire matrix is filled out. After phase II is completed, phase III operations delete all completed rows in matrix that have a zero in column 4 (i.e., no batteries available). Thus, after phase III operation, if, for example, there are no batteries of 8-inch howitzer capable of engaging the target, the decision matrix might look like one of the examples shown in Figure IV-17.

Figure IV-17--Decision Matrix Examples--Phase III

	Weapon	Volleys	Batteries Required	Batteries Available	Effective
DM IIIA =	155	3	2	8	100 percent
	8-inch	4	2	-	-
	105	12	3	-	-
	4.2	24	1	-	-

(or)

	Weapon	Volleys	Batteries Required	Batteries Available	Effective
DM IIIB =	155	3	2	1	80 percent
	105	12	3	2	96 percent
	4.2	24	2	-	-

(or)

	Weapon	Volleys	Batteries Required	Batteries Available	Effective
DM IIIC =	155	3	2	1	80 percent
	105	12	3	1	74 percent
	4.2	24	1	1	72 percent

(9) If stopping criteria have been met within the first three rows of the phase III matrix, such as in row one of DM_{IIIA} or row two of DM_{IIIB}, or if the completed phase III matrix has only one row (no example shown), then the decision taken is to fire without calibre mixing, that type of weapon system in the last completed row of the matrix. In the case where battery stopping criteria are met (such as in DM_{IIIA}), the model selects the required batteries in the following manner:

(a) If the mission is from a DS sensor, the first battery selected is the closest DS battery to the target. Additional batteries selected are DS batteries in order of closeness to target. If there are not enough available DS batteries to fill out the mission, the remaining requirements are met with GS batteries in order of closeness to the target.

** why closest? why not fire or [illegible]

(b) If the mission is from a GS sensor, the required batteries are selected from the available GS batteries in order of closeness to the target. If additional batteries are needed, they are selected from the available DS batteries in order of closeness to the target.

(10) In the case where efficiency stopping criteria have been met (as in DM_{IIIB}), all batteries available of that type are fired; and the volleys fired by each battery is adjusted above the battery constraint to permit 100 percent efficiency. In the case where no stopping criteria are met and there is only one type weapon system (no example shown), all available batteries are fired to achieve the 4-ton constraint. ?

(11) When no stopping criteria have been met and there is more than one row in the decision matrix after phase III, an attempt is made to mix calibers within two of the first three rows of the matrix

(if there are at least three rows). Only two calibers are permitted to be mixed on a given mission and the order of mix attempt is:

In general we attempt to mix arty round on targets from the division

(a) First and second row.

(b) First and third row (if there is a third row).

(c) Second and third row (if there is a third row).

In each case above, if a pair of rows is found in which the weapons are compatible for a mixed mission, all of the first type weapon batteries are selected for firing and as many of the second type batteries as necessary to achieve a combined mission efficiency of 100 percent are selected according to closeness to the target. All of the second type are selected also if a combined efficiency of 100 percent cannot be achieved. In the event that there are no caliber mix compatible weapons available, all rows of the decision matrix, except row one, are truncated, processing is returned to the non-caliber mix procedure and all available row one batteries are assigned to the mission.

(12) When the completed decision matrix after phase III has zero rows (no example shown), then all batteries are busy on other missions. If the target is a moving target, it is lost and the model skips to the next event. If the target is stationary, an attempt is made to schedule batteries for the mission in the future. The previously described decision process is repeated with the following exceptions.

(a) Batteries on the mission firing list at present are allowed to be put on the candidate list if they will become available within the next 5 minutes. ??

(b) Only the first row of the decision matrix is considered (i.e., the preferred weapon system). why

If no batteries became available within the future 5 minutes, the target is lost.

(13) After the model has selected particular batteries for the mission, it computes the number of volleys that each is to fire,

computes the time necessary to set up the mission, fires the mission and allows for tube cooling, and places the batteries on the mission firing list. These batteries are then precluded from accepting missions that become available until such time as they have completed the mission.

(14) The model assesses casualties in the target area and records cumulative totals of rounds fired by weapon and ammunition type and outputs a complete description of the event and all actions taken. Casualty assessment is based on input data from the Casualty Assessment Model (CAM) and is corrected by the model to account for errors made by the sensor in describing target size and type. On every mission, casualties are assessed on actual target/weapon information, while decisions are made based on sensed information. Thus, a target may be estimated by who to be defeated and in fact may not be; or a target may be estimated not to have been defeated, while in fact it has been.

(15) Finally, the model adjusts the information on the targeted unit to account for the actual effects of the fire mission. This adjustment is necessary to provide the base for assessing casualties against the unit if it is engaged again at a later time during the stylized period.

3. (U) ASSUMPTIONS. The following assumptions are inherent in the methodology employed in FPM.

a. All events described as acquired targets are not associated directly with the individual battles played in the Infantry Combat Model (ICM) or Tank/Anti-Tank Simulation Model (TATS). Artillery events from those situations are added to the acquired list as other events (final protective fires, prep fires, etc.).

b. Engagement of acquired targets assumes MET+VE fires, and casualty assessments are based on this assumption. This has the general effect of increasing the number of rounds required to achieve the defeat criteria for a given target.

c. The most cost effective type munition is employed on each fire mission for each type weapon system employed.

d. There is no constraint on the availability of ammunition to the firing battery, except that no more than 4 tons can be fired by a battery on any one mission; and no more than 15 tons can be fired at any target on any one mission.

must be some control due to upon [illegible]

e. Given that more than one weapon system type is available and able to engage a target effectively, that system is selected which can most economically achieve the defeat criteria. This assumes that decisions are made in the same manner during actual combat situations and that consuming units will be effectively constrained to make such decisions based on the approved rate.

f. No more than four batteries need be massed on a single mission. This assumption is based on the ability of four batteries to achieve the 15-ton target engagement constraint.

g. No significant attrition of artillery firing capability occurs within a 6-hour sytlized period. The effects of attrition of firing capability are accounted for in the Theater Rates Model (TRM), not in the Fire Planning Model.

h. Missions are processed on a first-acquired, first-fired basis. Battery resources, once committed to a mission, cannot be interrupted except to fulfill requirements of direct support to maneuver battaltions.

APPENDIX IX

THEATER RATES MODEL

1. (U) PURPOSE. The purpose of this appendix is to describe the methodology employed by the Theater Rates Model (TRM) to extrapolate stylized loss, casualty, and expenditure data from the Red Army slice and opposing Blue forces to the theater as a whole. Stylized US and enemy ammunition expenditures, personnel casualties, and tank and major weapon system losses for each of the 16 stylized periods analyzed in detail are input to the Theater Rates Model. The model combines this basic data (the results of high resolution models described in the remainder of this volume) with actual US and enemy unit deployments data and firepower capability to simulate theater combat over intense initial periods of conflict and subsequent sustaining periods in the European and Pacific theaters. The model produces a summary report at the end of each six-hour simulation period and computes the frequency of occurrence of the stylized combat periods in both theaters.

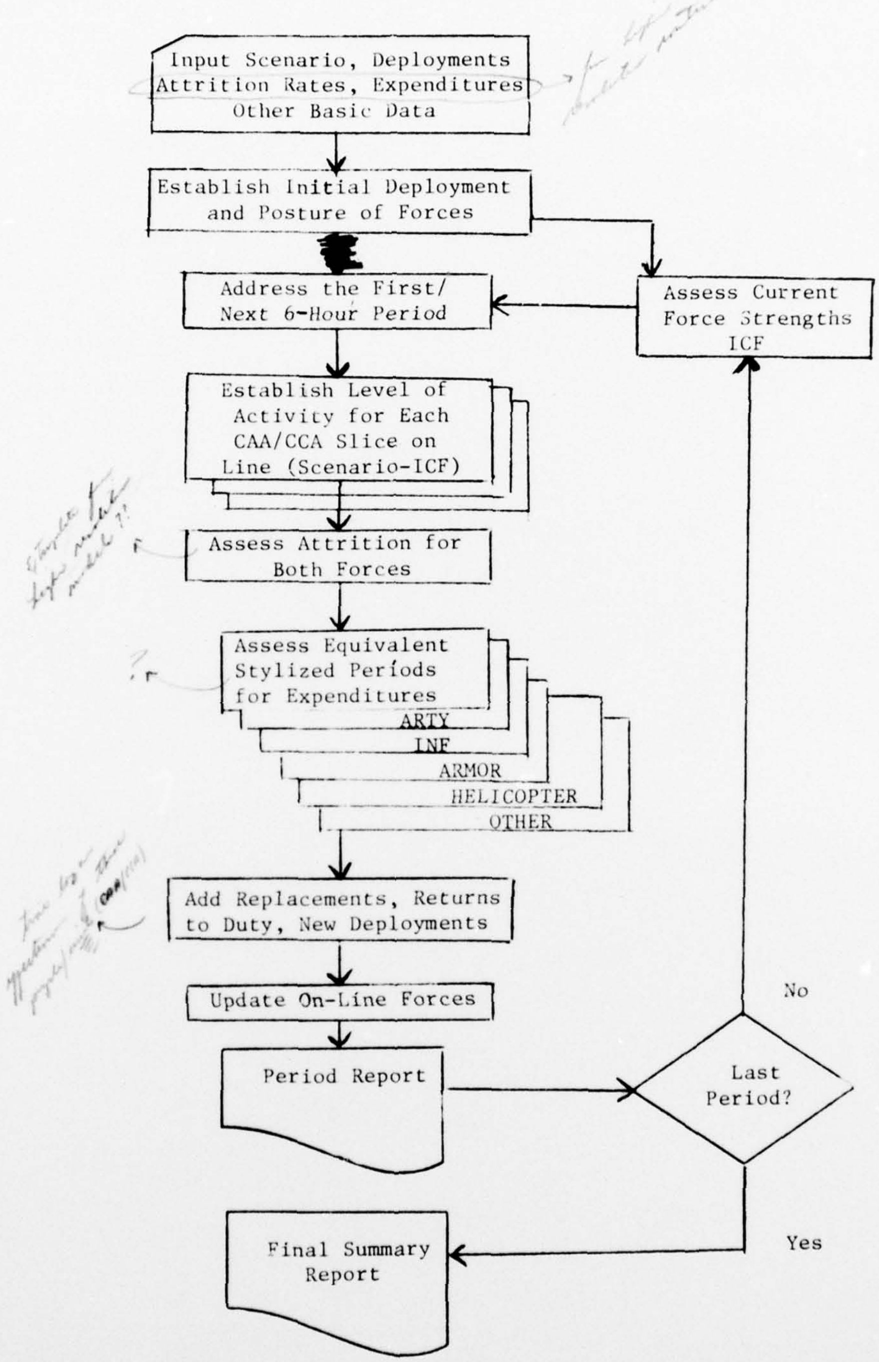
2. (U) METHODOLOGY

a. General

(1) The logic flow of the Theater Rates Model and the methodology used to determine the sequencing of the stylized combat periods over the simulated period of conflict are discussed in the following paragraphs. The logic flow is diagramed in Figure IV-18.

(2) The available US (Blue) forces and either the Soviet or Chinese Communist (Red) forces at the beginning of the conflict are input to the Theater Rates Model. Also, the width of the front for which the Blue forces are responsible is defined. The Index of Comparative Firepower (ICF) scores of the opposing forces is obtained and the ratio of the enemy ICF score to the US ICF score is then combined with an input scenario to characterize the activity across the Blue front. The characterization delineates the number of Combined Arms Army (CAA) or

Figure IV-18--Logic Flow of Theater Rates Model



Chinese Communist Armies (CCA) engaged at each of the four levels of activity defined by the stylized combat periods. The activity across the front is normalized to the CAA or CCA to be consistent with the method used to define the forces arrayed in each of the stylized combat periods.

(3) The results of the analysis of the stylized combat periods are then multiplied by the number of CAA or CCA at each level of activity to produce the Blue ammunition expenditures and the resulting friendly and enemy casualties, tank losses, and major weapon system losses for the first 6 hours of conflict. All estimates of Red and Blue casualties, tank losses, and major weapon losses for the stylized periods are produced by high resolution models without use of historical exchange ratios.

(4) After the results of the initial index period have been obtained, the ICF scores of the opposing forces are adjusted to account for tank losses and casualties. Any reinforcements and replacements or returns to duty available to the forces are considered, and ICF's are increased accordingly. A new front ICF ratio is then calculated, changes in scenario are considered, and this information is used to define the frontal activity of the next index period.

(5) As the conflict progresses and each index period is evaluated, the ammunition expenditures, tank losses, and casualties obtained for the stylized combat periods must reflect the attrition of forces on both sides to depict realistically the results of the actions. The effects of attrition on the opposing forces are threefold. First, the casualties and tank and helicopter losses received by the US forces in previous periods degrade their ability to expend ammunition during subsequent periods. Therefore, there is a reduction in the US casualty-producing potential. Second, the casulaties incurred by enemy targets during the previous periods deplete the personnel density of the enemy targets on which the US forces can fire. This reduces the casualties

incurred by the enemy. The effects of these first two phenomena are evaluated for each 6-hour period during the period of conflict. The third effect of attrition on the results of the stylized combat periods is related to tank, TOW, DRAGON, and helicopter loss rates. A separate evaluation of these losses for the combat period being evaluated is performed.

(6) A cumulative total of the ammunition expenditure, tank and major weapon losses, and casualties is kept for each index period and is totaled at the end of the duration of combat for each theater.

(7) The preceding is only an overview of the play of the Theater Rates Model. The rules governing each of the steps in the model will be described in detail in the succeeding paragraphs.

b. Combat Effectiveness and Comparative Firepower

(1) Important to the operation of the Theater Rates Model is the measurement of the relative strength of opposing forces. The Index of Comparative Firepower (ICF) provides this measure. The ICF is a score based on the total firepower potential of any unit or force, normalized to the ICF of a US Infantry Division which is established as 1.00. The ICF method has recognized limitations. It assumes that other factors which influence combat effectiveness, such as the state of training and experience, resupply, intelligence, mobility, and morale, are comparable for opposing forces. While not a perfect method of measuring combat effectiveness, the ICF system provides the degree of comparison between units necessary for this study and is considered sufficiently precise for use in the Theater Rates Model.

(2) Unit firepower potentials (FPP's) used in the calculation of ICF's are not a function of the recommended ammunition rates produced by the study. Subsequent to analysis of the interplay of ammunition rates and the expected expenditures of ammunition (EEA) needed in the computation of FPP's, procedural changes were made in the computation of

EEA which eliminate the inter-dependency of ammunition rates and firepower potential scores. This procedure involves determination of EEA as a function of the high-resolution stylized period results compared to the number of effective weapons producing the stylized expenditures. The procedure applies to both Red and Blue force EEA.

(3) Certain limitations are placed on the number of units considered on each side based on doctrine and the capability to influence the combat. In this study all divisions deployed along the FEBA and their immediate reserves are considered when determining the ICF ratio. This means for the Soviets that all of the units in the CAA deployed along the FEBA are considered contributing to the total enemy ICF score. The Soviet front reserves are not included. The same is true of the ChiCom in Korea. For Blue forces in both Europe and Korea, the divisions deployed along the FEBA and their corps reserves are considered contributing to the friendly ICF score. The field army reserves are not included in the friendly ICF score.

(4) To determine the forces available to be deployed along the FEBA, a decision on what forces will be committed by each side is made. There are some restrictions on the frontage of units on both sides; and, also, the strength of the units in reserve must be considered. In this case, it is assumed that the enemy will commit all the forces available to them except that the Soviets will keep one CAA and the ChiCom one CCA in front reserve unless maximum frontage constraints are violated. The US forces will also commit all their available forces except for one division in army reserve. The other restriction on committing enemy forces is that the average frontage of the units deployed along the FEBA does not violate doctrinal frontage limitations. → could be contested. under what they play?

c. *Composition of the Combat Activity*

(1) The enemy forces in both Europe and Korea will usually have the initial advantage in the ICF ratio. This situation permits the

enemy to dictate the levels of combat activity occurring across the front the Blue forces are covering. Although it is impossible to predict the exact levels of combat activity occurring across the front, it is possible to present the most probable combination of combat activities that could occur for specific front ICF ratios. This range of activity can be defined by constructing the matrices of front activity levels versus front ICF ratios. These matrices can be determined by examining tactics of the enemy and the most logical tactics of the US forces in attempting to defeat the enemy.

(2) When ICF ratios are used to determine combat activity, the rules employed to define the US and enemy tactics and to select the activity are as follow:

(a) Enemy Tactics. Soviet and ChiCom doctrine indicates that they will attack and attempt to penetrate whenever and wherever possible.

(b) US Tactics. The US forces will deploy to meet the enemy's attack and, if possible, limit the enemy's penetration. The US forces will also seek to continuously cause the enemy attrition and to assume the offensive in order to regain control if the situation permits.

(3) Application of these rules has resulted in use of the following relationships between levels of activity and ICF.

(a) ICF Ratio ≈ 3.25: The Red force attacks and the Blue force is in delay.

(b) ICF Ratio ≈ 2.00: The Red force attacks and the Blue force is in an intense defense.

(c) ICF Ratio ≈ 1.00; The Red and Blue forces are both in a light defense posture in preparation for subsequent action.

(d) ICF Ratio ≈ .50: The Blue force attacks and the Red force is in a hasty defense.

(4) Employing these rules for tactics and ICF ratios, the composition of the combat activity is given by the following set of equations.

Let

$$\text{FICF} = \text{front ICF ratio} \tag{1}$$

$$\text{FICF} \geqq 3.25$$

Then, <u>100 percent of front is in delay.</u>

If

$$3.25 > \text{FICF} \geqq 2.00 \tag{2}$$

Then

$$\text{FICF} = 3.25(x) + 2.00\,(1-x)$$

will always give you the <u>largest</u> possible portion of the front in delay & <u>smallest</u> part in intense defense for a given FICF

$$x = \frac{\text{FICF} - 2.00}{1.25}$$

Where

x = fraction of front in delay

$1-x$ = fraction of front in defense intense.

Only allows 2 (3 on pg C-IX-5) levels of activity along the enemy's front at any time.

If

$$2.00 > \text{FICF} \geqq 1.00 \tag{3}$$

Then

$$\text{FICF} = 2.00(x) + 1.00\,(1-x)$$

$$x = \text{FICF} - 1.$$

Where

x = fraction of front in defense intense.

$1-x$ = fraction of front in defense light.

If

$$1.00 > \text{FICF} \geqq 0.5 \tag{4}$$

Then

$$\text{FICF} = 1.00(x) + 0.5(1-x)$$

$$x = \frac{\text{FICF} - 0.5}{0.5}$$

Where

x = fraction of front in defense light.

$1-x$ = fraction of front in attack.

If

$$FICF < 0.5 \tag{5}$$

Then, 100 percent of the front is in attack.

d. Effect of Scenario

(1) The composition of the combat activity as determined by the ICF ratio can be modified by an input activity scenario. This scenario specifies the overall level of activity of the Blue force and is reflective of the theater plans or intention. An example of such a scenario is: US forces will delay from D-Day to D+5 and will defend from D+5 to D+15, etc.

(2) The Theater Rates Model allows for the linear combination of ICF ratio considerations and scenario considerations by use of weighting factors.

Let:

x = fraction of the front at activity level I, as determined by FICF.

y = fraction of the front at activity level J, as determined by FICF.

Where I and J are from the set of activities Delay, Defense Intense, Defense Light, Attack

$$0.0 \leq x \text{ and } y \leq 1.0 \tag{6}$$

$$x + y = 1.0 \tag{7}$$

and

$$I \neq J \tag{8}$$

Also, let: p = weighting given to ICF ratio

q = weighting given to scenario

K = level of activity specified by the scenario

Where

$$0.0 \leq p \text{ and } q \geq 1.0 \qquad (9)$$

$$p + q = 1.0 \qquad (10)$$

and

K is from the set of activities Delay, Defense Intense, Defense Light, Attack.

Then, the composition of the index period is determined as follows:

Let i, j, k = fraction of index period at activity level I, J, K.

Then:

$$i = px \qquad (11)$$

$$j = py \qquad (12)$$

$$k = q \qquad (13)$$

$px + py + q \overset{?}{=} 1$

$p(\underbrace{x+y}_{=1}) + q = 1$

$p + q = 1$

QED

such that:

$$i + j + k = 1.0 \qquad (14)$$

(3) The combat activity which results from the combination of ICF and scenario can place the theater front in either one, two, or three distinct activity levels.

(4) The number of CAA's or CCA's at each level of combat activity is obtained by applying the fraction of the front at each level to the number of CAA's or CCA's on line.

e. Effects of Attrition on the Results of the Stylized Combat Periods

(1) General. The attrition of the opposing forces from previous periods must be considered when determining the losses and expenditures for the period being evaluated. The effects of attrition on the results of the stylized combat periods are twofold and apply differently to each type activity for which the Theater Rates Model keeps account.

(a) The attrition of the Red or Blue force reduces its ability to bring firepower to bear on the opposing force. This

reduction in firepower capability is not linear with respect to the net casualties (total casualties minus replacement and returns-to-duty). The nonlinearity of the reduction is caused partly by the fact that personnel are cross-trained in the unit's weapons; and when casualties do occur in units, the weapons with the most firepower will be kept in action. Also, the unit commander has the option of replacing some of the casualties which the unit suffers in combat personnel with support personnel. There are no accurate measurements of the relationship of casualties to reduction for firepower as a result of test data or actual combat data. However, the reduction of the firepower of units as a result of casualties has been estimated by military experts. Firepower reductions due to casualties and losses in infantry, armor, and artillery units, as used in this methodology, are contained in Basic Data, Annex D. Vol II

This effect of attrition is subsequently referred to as a reduction in ability to fire.

(b) The attrition of the Red and Blue force reduces either the density of existing units or the total number of units in the force. These phenoma affect the casualties and losses that occur in an engaged or targeted unit and may also affect the number of units engaged or targeted. This effect of attrition is subsequently referred to as reduction in ability to engage or ability to acquire.

(2) Equivalent Stylized Periods. The primary calculation within the Theater Rates Model, directly affecting ammunition rates, is concerned with estimating equivalent stylized periods. An equivalent stylized period is considered to be a unit of activity over some period of time which is characterized by the same expenditures, casualties, and losses of a stylized period. Considered in the equivalent stylized period is the attrition from all previous index periods and the effects that the attrition has on losses and expenditures. For example, if on two successive mornings between 0600 and 1200 hours a CAA at 70 percent

AD-A047 861 ARMY CONCEPTS ANALYSIS AGENCY BETHESDA MD F/G 19/1
NONNUCLEAR AMMUNITION COMBAT RATES PROGRAMMING FY 75/79 (AMMO75--ETC(U)
JUL 73

UNCLASSIFIED NL

2 OF 2
AD A047861

END
DATE FILMED
1 -78
DDC

6 hour period!!

?

strength opposes a delaying Blue force at 65 percent strength, the methodology might specify that infantry-related expenditures and losses for that 12-hour period are the same as losses and expenditures for one full strength stylized 0600-1200 period in delay. The determination of equivalent stylized periods is the main thrust of the Theater Rates Model. The effects of attrition which drive this determination are detailed below. Separate equivalent stylized periods are accumulated for different types of activities.

(3) Infantry Activity. Infantry equivalent stylized periods are calculated on the basis of ability of Blue forces to fire. The model keeps a period by period account of on-line troop strength initial (full strength) and on-line troop strength current and calculates equivalent stylized infantry period (BIC) in the following manner:

$$\text{BIC} = f\left(\frac{\text{current troop strength}}{\text{full troop strength}}\right) \qquad (15)$$

Where f(x) is the effectiveness of infantry units at x strength level. Attrition rates associated with infantry activities are adjusted linearly for Red and Blue on the basis of the ability of the opposing force to fire and on the remaining personnel of the force sustaining losses.

(4) Armor Activity. Armor equivalent stylized periods are calculated on the basis of ability to fire and ability to engage. The model keeps a period by period account of initial tank strength (full strength) and current tank strength for both Red and Blue on-line forces and calculates armor equivalent stylized periods (BTK) in the following manner:

$$\text{BTK} = \text{MIN}\ (\text{B},\text{R}) \qquad (16)$$

Where

$$\text{R} = g\left(\frac{\text{Red current tank strength}}{\text{Red full tank strength}}\right) \qquad (17)$$

$$\text{B} = g\left(\frac{\text{Blue current tank strength}}{\text{Blue full tank strength}}\right) \qquad (18)$$

and $g(x)$ is the effectiveness of armor units at x strength level. The equivalent stylized periods are based on the minimum of B and R to indicate that an enemy force with overwhelming tank superiority cannot bring all of that strength to bear on friendly armor units. Attrition rates associated with armor activity are adjusted for Red and Blue on the basis of the number of small tank battles that can take place with the attrited level of tanks available.

(5) Artillery Activity. Artillery equivalent stylized periods are calculated based on ability to fire and ability to acquire. Equivalent period accounts are kept for both Red and Blue forces and with Blue artillery periods. A distinction is made between artillery fires directed at armor targets and artillery fires directed at non-armor targets.

(a) Artillery equivalent stylized periods for armor targets (BTF) are calculated on the basis of Blue ability to fire (measured by personnel strength) and Blue ability to acquire armor targets (measured by enemy tank strength) as follows:

$$BTF = MIN\ (B,R) \tag{19}$$

Where

$$B = h\left(\frac{\text{Blue current troop strength}}{\text{Blue full troop strength}}\right) \tag{20}$$

$$R = h\left(\frac{\text{Red current tank strength}}{\text{Red full tank strength}}\right) \tag{21}$$

and $h(x)$ is the effectiveness of artillery units at x strength level.

(b) Artillery equivalent stylized periods for non-armor targets (BIF) are calculated on the basis of Blue ability to fire (measured by personnel strength) and Blue ability to acquire non-armor targets measured by Red personnel strength as follows:

$$BIF = MIN\ (B,R) \tag{22}$$

Where

$$B = h\left(\frac{\text{Blue current troop strength}}{\text{Blue full troop strength}}\right) \tag{23}$$

$$R = i\left(\frac{\text{Red current troop strength}}{\text{Red full troop strength}}\right) \tag{24}$$

and h(x) is the effectiveness of artillery units at x strength level; and i(x) is a reduction function indicating Red doctrine of consolidation of units as troop strength is significantly reduced (see Basic Data, annex D). In addition to these reductions resulting from attrition of forces, Blue artillery fires against non-armor targets are allowed to increase in certain instances. If the reduction in artillery fires against armor targets is greater than the reduction in Blue's ability to fire (i.e., these fires are contorolled by Blue's ability to acquire armor targets), Blue artillery fires against non-armor targets are allowed to increase, but not beyond friendly ability to acquire non-armor targets.

(c) Red artillery equivalent stylized periods (RIF) are calculated on the basis of Red's ability to fire and ability to acquire as follows:

$$RIF = MIN\ (B,R) \tag{25}$$

Where

$$B = h\left(\frac{\text{current Blue troop strength}}{\text{full Blue troop strength}}\right) \tag{26}$$

$$R = h\left(\frac{\text{current Red troop strength}}{\text{full Red troop strength}}\right) \tag{27}$$

and h(x) is the effectiveness of artillery units at x strength level.

(d) Attrition rates and losses for Red and Blue forces associated with artillery fires are adjusted on the basis of the opposing force ability to fire and on the stylized density of the force sustaining losses.

(6) Helicopter Activity. Helicopter equivalent stylized periods are calculated on the basis of Blue's ability to fire. The model keeps a period-by-period account of current attack helicopter strength and stylized helicopter strength. A separate accounting is made for anti-armor attack helicopters and anti-personnel attack helicopters.

(a) Helicopter anti-armor equivalent stylized periods (BHT) are calculated on the ability of the aircraft to fly anti-armor sorties, as follows:

$$BHT = \left(\frac{\text{current anti-armor helicopter strength}}{\text{stylized anti-armor helicopter strength}}\right) \qquad (28)$$

(b) Helicopter anti-personnel equivalent stylized periods (BHP) are calculated on Blue ability to fly anti-personnel sorties as follows:

$$BHP = \left(\frac{\text{current anti-personnel helicopter strength}}{\text{stylized anti-personnel helicopter strength}}\right) \qquad (29)$$

(c) Attrition rates and losses associated with attack helicopter activity are adjusted on the basis of actual Blue sortie rates and current Red density and effectiveness.

(7) Other Activities. An equivalent stylized period account is kept for two separate weapon systems, the TOW and the DRAGON. DRAGON equivalent stylized periods (BDR) and TOW equivalent stylized periods (BAT [redacted]) follows:

$$BDR = MIN\ (B,R) \qquad (30)$$

Where

$$B = \left(\frac{\text{current Blue DRAGON strength}}{\text{full Blue DRAGON strength}}\right) \qquad (31)$$

BTW?

$$R = \left(\frac{\text{current Red tank strength}}{\text{full Red tank strength}}\right) \qquad (32)$$

$$BAT = MIN\ (B,R) \qquad (33)$$

Where

$$B = \left(\frac{\text{current Blue TOW strength}}{\text{stylized Blue TOW strength}}\right) \qquad (34)$$

and R is defined as in (32) above. Red and Blue attrition rates and losses associated with TOW and DRAGON are adjusted based on ability to fire by the opposing force and on the current density of the force sustaining losses.

f. Effects of Attrition on Forces Deplc

(1) The effects of attrition on bc ue and Red forces are measured by the reduction of the front ICF scor oth sides and

adjustments of the front ICF [illegible]. Which units are affected and how much their ICF scores are changed are considered in this section.

(2) The detail required in determining which units' ICF scores are affected by attrition is governed by the reinforcement and replacement policies of the opposing forces. The policies of the US and enemy forces differ. The US forces replace casualties individually by personnel from a replacement pool. The enemy forces, however, are assumed to replace casualties on a unit basis; that is to say, an enemy unit is kept on line until its personnel strength is reduced to two-thirds its original strength. ?

(3) The rules that determine which units' ICF scores are affected by casualties and tank losses are as follows.

(a) Enemy units, both combat and support, that are in their committed zone suffer combat casualties and tank losses. The enemy's committed zone is considered to extend back from the FEBA to a depth equal to the zone of responsibility of a CAA or CCA. Because the enemy replaces by unit at a division level, an exact accounting of casualties occurring in each division in the CAA or CCA deployed along the FEBA and operating at the various levels of combat activity should be kept. This is not possible within the methodology used in determining the enemy casualties for the stylized combat periods since the unit of resolution in the Theater Rates Model is either a CAA or CCA. In this study, therefore, the replacements of units will be made at the CAA or CCA level. The CAA or CCA commander has the option of replacing ~~and~~ or reinforcing his divisions on line with units from his reserve division and, in all probability, when the divisions on line approach two-thirds of their original (or authorized) ??? strength the reserve division will be committed and it will be withdrawn at approximately the same time as other divisions in the CAA or CCA.

(b) In the initial 0001-0400 period, the specific CAA or CCA at each level of combat activity are selected randomly since they ?

are all at the same level of capability (full strength). The number of units at each level is, of course, governed by the front ICF ratio as described previously. When a specific CAA or CCA is assigned a level of activity, there is assigned an associated ICF ratio. At the start of each subsequent period, the level of combat activity level is examined in order of descending ICF ratio. The delay period is examined first; it is followed by the defense intense period and defense light period, with the attack period last. If the number of armies in the higher ICF ratio remains unchanged, each CAA or CCA in that activity remains in that activity unless it reaches the withdrawal point of two-thirds its initial force strength. Withdrawn armies are replaced with noncommitted armies if it is the start of a period two (0601 to 1200) and if any such units are available in reserve status. If a shift in the level of activity of units is necessary, the change is made by adjusting the level of activity of units previously operating at ICF ratios closest to those where the shift is required.

(c) If the number of CAA's or CCA's in the higher activity level is increased as a result of a change in the ICF ratio and frontal activity, armies are added to that activity level under the same rules as the replacement of a withdrawn unit. If the number of CAA's or CCA's in the higher posture is decreased, the reduction is made by transferring the CAA or CCA with the lowest current troop strength to the lower combat activity level.

(d) All the US units in the committed zone are affected by combat casualties and tank losses. The US committed zone is considered to have the same depth from the FEBA as the enemy's committed zone. All units in both the committed and reserve status incur noncombat casualties. Although combat casualties will not occur equally in all US units, the reduction of ICF scores of US forces in the committed status will be kept equal by allowing selective personnel and tank replacement policies.

Therefore, it is not necessary to designate which US divisions are functioning at the various levels of combat activity.

(4) The amount of reduction in the ICF score of both the friendly and enemy forces due to attrition is calculated by considering both the net personnel casualties and tank losses incurred by the forces. The relationship of ICF reduction to tank losses is considered to be linear for both forces. This linear relationship is considered valid because the tank itself is the target; the main objective of firing at it is to destroy the tank. Since the weapons on the tank are the source of its contribution to the forces' ICF scores, when these are lost the ICF scores should be reduced linearly.

(5) To obtain the total reduction of the opposing forces' ICF scores due to attition, the ICF losses due to net casualties must be added to the net ICF losses incurrred by tanks being destroyed. The loss of ICF due to casualties is considered to be nonlinear and to have a relationship to net percent casualties as contained in Basic Data, Annex D. This relationship considers all casualties except the casualties incurred from tank losses (two casualties per tank loss).

(6) In summary, the effects of attrition on ICF scores are considered to be twofold. The tank losses give a linear degradation to the ICF of units, while casualties degrade ICF scores nonlinearly. The total of these losses is the measure of the reduction of the forces' ICF scores for each combat period.

g. Return-to-Duty Schedules for Personnel and Tanks

(1) A certain portion of both battle and nonbattle casualties are returned to duty prior to the end of the conflict period. The method employed in this model for the return-to-duty of casualties for both the US and enemy forces is as follows.

(2) In both Europe and Korea, a US evacuation policy of 30 days is assumed. Within the 30 days, it is estimated that 20 percent of

the combat casualties[13] and 88 percent of the noncombat casualties[14] can be returned to duty. Combat casualties are returned to their units at the start of period two on the fifteenth day[15] after they become casualties. Noncombat casualties are returned at the start of period two on the eighth day[16] after they become casualties.

(3) The Soviet return-to-duty schedule is taken to be the same as that for the United States except that if a unit has been reconstituted prior to the return-to-duty of some of its casualties, those which do return are returned to the reconstitution pool instead of to the unit.

(4) The ChiCom forces are assumed to practice a 20-day evacuation policy, which combined with the known weaknesses in their medical service results in a return-to-duty rate of considerably less than that of the US or Soviets. It is assumed that only 5 percent of the combat casualties and 45 percent of the noncombat casualties return to duty. Combat casualties are assumed to return in 10 days and noncombat casualties in 4 days. The more rapid return is a direct result of a shorter evacuation policy. The ChiCom return-to-duty personnel are added to the reconstitution pool in the same manner as the Soviet return-to-duty personnel.

(5) The tank return-to-duty schedules are assumed to be the same for the US, Soviets, and ChiCom and are based upon US estimates. The Tank/Anti-Tank Model computes the number of tank losses (i.e., fire-

---

[13]US Army Combat Developments Command, Chemical-Biological-Radiological Agency, Addendum Study, Project Mandrake Root, "A Tactical Chemical Biological Operations Study (U)," Annex K, FT McClellan, Alabama, June 1967 (SECRET-RE-NOFORN).

[14]Department of the Army, FM 101-10-1, Staff Officers' Field Manual Organization, Technical, and Logistical Data-Unclassified Data, Washington, D.C., January 1966 (UNCLASSIFIED).

[15]US Army CDC, CBRA, "Project Mandrake Root," op. cit.

[16]Department of the Army FM 101-10-1, op. cit.

power, mobility, or total destruction). The other models provide only total kills. Based upon kill probabilities, 60 percent of all tank losses are taken as nonrepairable.

(6) Military estimates are that for repairable tanks 58 percent can be repaired within the tank battalion area and 32 percent must be withdrawn to a higher echelon for repair and that in the repair process 10 percent are deemed nonrepairable. The downtime for the tanks repaired within the battalion area is taken to be 3 days. Tanks which must be repaired at a higher echelon are given a downtime of 4 days, but these may be replaced in 3 days by tanks from the replacement pool (including the maintenance float) if any are available. In this case, the repaired tanks will be entered in the replacement pool 4 days after they are damaged. All returns to duty are made at 0601 on the day of return.

h. Reinforcement and Replacement Schedules

(1) United States doctrine calls for the individual replacement of casualties. The number of US replacements available are provided as input and are specified in Basic Data, Annex D. These replacements are assumed to be available at a constant rate throughout the duration of combat are distributed to all committed units in proportion to their personnel losses. If replacements are available in greater numbers than needed, they are held in a replacement pool to be utilized when they are needed. Replacements are entered at 0601 of each day.

(2) The Soviets and ChiComs utilize unit replacement of casualties. In this methodology, a CAA or CCA remains in combat status until its troop strength is depleted to two-thirds its original strength. The unit is then withdrawn and placed in a reconstitution status. If no unit is available to replace to replace the withdrawn CAA or CCA, and if withdrawal would result in extension of on-line frontage for an army beyond doctrinal guidance concerning the maximum front that can be engaged by the remaining on-line armies, the model prevents withdrawal until such time as a replacement army is available.

(3) Troops from withdrawn armies remain in the reconstitution status for a minimum of 7 days and until there is sufficient troop strength in this status to combine with any reinforcement and returns-to-duty to form a full strength CAA or CCA. The reconstituted army is then transferred to either combat or reserve status depending upon frontage limitations. In reconstitution, the tank forces is brought up to full strength if tanks are available. If not, the units can be committed at actual tank strength.

(4) Tanks which have been destroyed or which cannot be recovered can be replaced in 3 days by tanks from the replacement pool. The same is true of those damaged tanks which cannot be repaired within 3 days. If a damaged tank is replaced by a tank from the replacement pool, the damaged tank is added to the pool when it is repaired (4 days after it is damaged). The replacement pool is comprised of all tanks, except TOE strength of the units, initially in theater or entering it during the period of combat. Tanks are entered into and withdrawn from the replacement pool at the start of period two.

(5) Units arriving in the theater after D-Day are committed to the conflict at the start of period two after that day on which they are considered to be available to the front. Definitions of type Red and Blue units and unit slices played in the Theater Rates Model are contained in Basic Data, Annex D.

3. (U) ASSUMPTIONS. The following assumptions are inherent in the methodology employed by the Theater Rates Model.

a. In this study, it is assumed that the enemy will initially commit all the forces available to them except that the Soviets will keep one CAA and the ChiCom one CCA in front reserve. The Blue force will also commit all their available forces except for one division in Army reserve. The assumptions are restricted so that the average frontage of the units deployed along the FEBA does not violate doctrinal frontage limitations. The limitations are specified in detail in Basic Data, Annex D.

b. It is assumed that the scenario will be followed by Blue forces in a manner which precludes losses of major units due to encirclement and that the integrity of the FEBA can be maintained to preclude flank attacks.

c. Separate account is not kept of on-line inventories of weapon systems with the exception of tanks, helicopters, TOW, and DRAGON. It is assumed that those expenditures of ammunition not directly related to these weapons (namely, small arms, mortars, and artillery) can be related to troop strengths.

d. The Theater Rates Model does not play FEBA movement; all stylized arrays used in detailed, high resolution analysis are played in the same terrain. This terrain is selected as being typical of the terrain in the theater of conflict. It is assumed that terrain changes caused by FEBA movement during the conflict are not significantly different from the stylized terrain.

e. The Red unit of resolution in this model is a nominal CAA or CCA. An analysis is made with a composite army based upon a mix of motorized rifle divisions and tank divisions. The division is determined by the enemy total deployment of type divisions. It is assumed for the purpose of ammunition expenditure analysis that the enemy will form armies in this manner (as stylized). It is necessary to perform analysis on such a composite army to insure that enemy weapons are properly stylized in relation to actual deployed weapons densities.

f. Detailed analysis is made for one type enemy army slice facing a friendly force of the required size to accomplish the friendly mission (delay, defend, etc.) vis-a-vis the enemy force. The model extrapolates this data to all enemy army slices on line on any given day (considering, of course, the effects of attrition on both Red and Blue forces) as though they were the force stylized in detail. It is assumed that if identical enemy armies engaged identical Blue forces side by side and at the same level of activity, losses and expenditures would be identical.

g. Use of firepower ratios to establish the levels of activity across the FEBA during any time period assumes that combat activity levels are actually determined by true force firepower potentials. That is to say, a force will delay only when it is not capable of defending or attacking, or a force defends rather than delaying only when it is not capable of attacking and a force attacks whenever it is capable of doing so.

h. Use of scenario to establish the level of activity across the FEBA during any time period assumes that the existing (current) Blue force is capable of implementing the scenario activity. For example, if the scenario specifies that Blue defends on a given day, the methodology assumes that Blue has sufficient strength vis-a-vis the enemy force, to defend on that day. ICF calculations for that day might suggest that Blue is only capable of delay.

i. It is assumed that the USAF achieves air superiority by D+30.

j. It is assumed that the US Air Force can interdict Red lines of communication to limit additional Red units to six divisions after Blue air superiority has been established and that no personnel or tank replacements penetrate the interdiction effort during the 90-day intense period.

k. It is assumed that during D+90 to D+180 the Red forces deploy only enough personnel and tank replacements to meet anticipated losses. Also, that 30 percent of the tank replacements do not arrive in theater because of 10 percent loss to air interdiction and 20 percent operational losses in moving the tanks.